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Engineering News-Record

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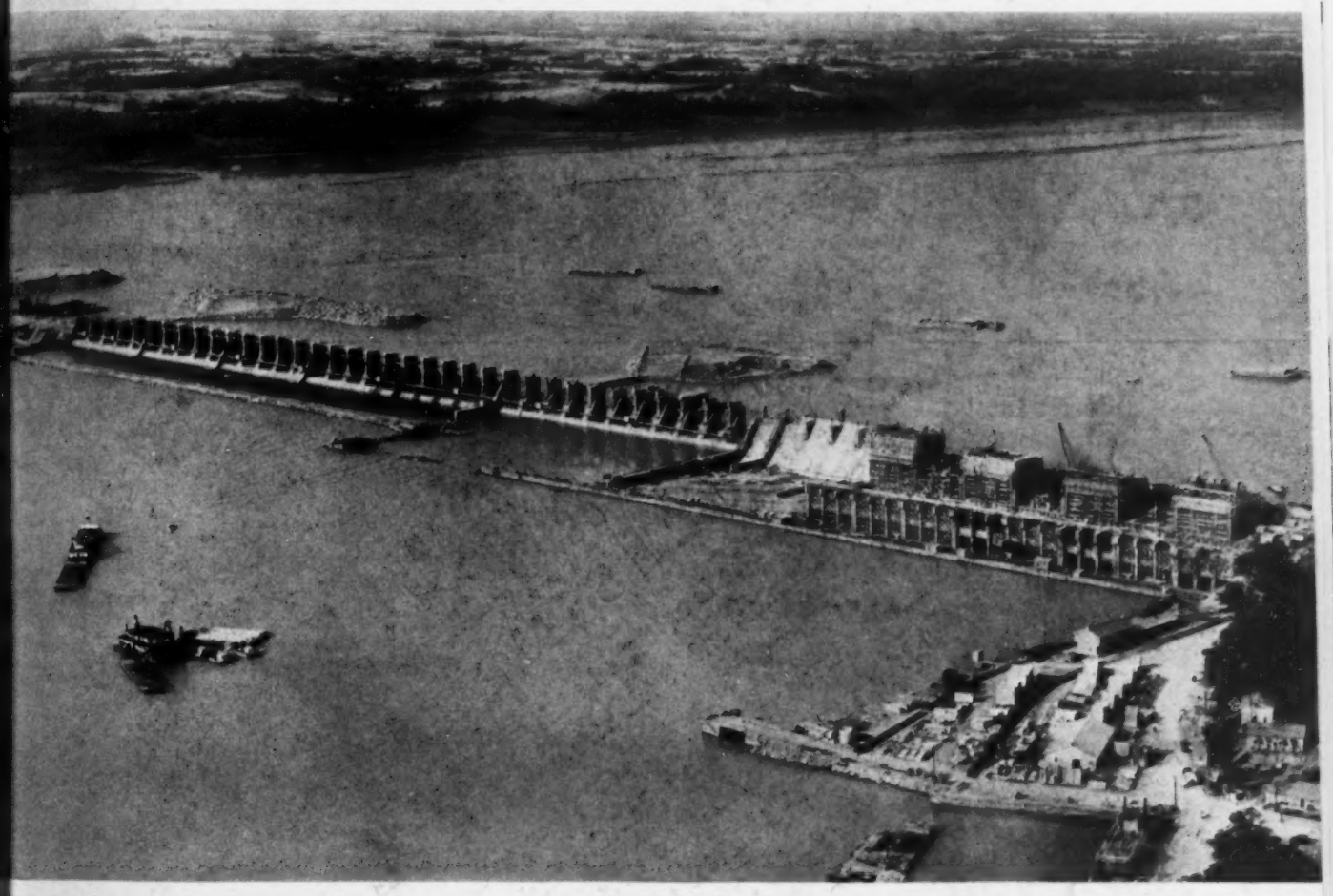

Wheeler Dam on the Tennessee River will be 6,400 ft. long when completed. The work here shown has reduced the channel to 2,200 ft. In the near future cofferdams for the remainder will be built, the flow being handled through the openings left in the part now under construction.

Battling Storm and Tide in Founding Golden Gate Bridge Pier

Watertight Pump Chamber for Flooding Tunnel

Early Days at Panama — Another of John F. Stevens' Recollections

Wheeler Dam Construction Enters Final Year

NEW BOOKS IN THE CIVIL ENGINEERING FIELD

All-time record set at Fort Peck Dam: 944,000 cu. yds. of dirt loaded in 45 fourteen-hour days! Here are two of the three "Caterpillar" Diesel Tractors and "Caterpillar" Elevating Graders that did it.

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THIS ADVERTISEMENT speaks especially to small home owners. But what it says has a much broader application and touches one of the factors that are responsible for our recurrent economic disturbances.

The home owner is not the only one who suffers because he has been taught by those who should know better that debts need not be paid off, that they can be indefinitely stalled or, in the jargon of high finance, refunded. The principle here laid down should be pondered by every user of capital —industrialists, building owners, railroad and utility operators as well as home-owners—and by every investor whose capital they seek.

THE interminable refunding of old debt, the piling of new debt for necessary improvements on top of old debt that represents vanished values, the naïve assumption that the creation of new corporate units with new obligations (all based on the same old productive facilities) somehow justifies the added debt—all these remind us vividly of the incomparable Wilkins Micawber and his bland assumption that when he delivered a new I.O.U. he thereby liquidated his indebtedness. We smile at Micawber but his financial technique too often has dominated American financial practice.

Much of this madness stems from a failure to recognize that the essential difference between consumable goods and capital goods is one of time. We all know that the former are quickly used up; therefore we must pay for them out of current income. But we seem to cherish the delusion that the latter last forever; therefore we need never pay for them. We do not seem to see that on the very instant they come into being they begin to pass into consumption. Whether they last for five years or fifty years the debt incurred to create them must be extinguished within that period. Otherwise our economy is bound to get out of whack and we must suffer these periodical orgies of repudiation that we call depression.

WE seem to forget also that, aside from wear and tear, capital goods are subject to a more insidious and often a more speedy form of consumption. That is obsolescence, that subtle influence which may attack values so imperceptibly that long after the meat has been sucked from the investment, the bones of debt remain, a blight on the efforts of the most competent management to prosper or survive against less encumbered competition.

Of the debt so blithely incurred for sheer speculation, no account need be taken here. That, of course, produces nothing of value and is but a gratuitous tax on the actual producers and productive capacity of the country. It is an economic plague and should be dealt with as such. Here we are considering only productive debt which provides truly productive facilities that add to our wealth, employment, incomes and earned profits, that are responsible for higher standards of living and for our consistent conquest of scarcity. But if we are to push that conquest we must learn how to cut the losses that are inherent in these periodical purges: we must learn that new issues of securities do not necessarily create new wealth—they may be but added claims against existing wealth, that capital facilities are consumed just as truly as are food and clothing and debt incurred to create them must be retired within their productive lives, that every corporate and financial device that obscures these fundamentals is a menace to the survival of our economic order.

NO ONE should be more deeply concerned about all this than those whose business it is to design and build the capital facilities that are so necessary to modern life. While we take heart from the evidence of returning sanity revealed in this advertisement, we must do all we can to keep these principles before those who provide and use capital for productive purposes and to write them into the financial and corporate law of the land.

Willard Chevalier

ENGINEERING NEWS-RECORD

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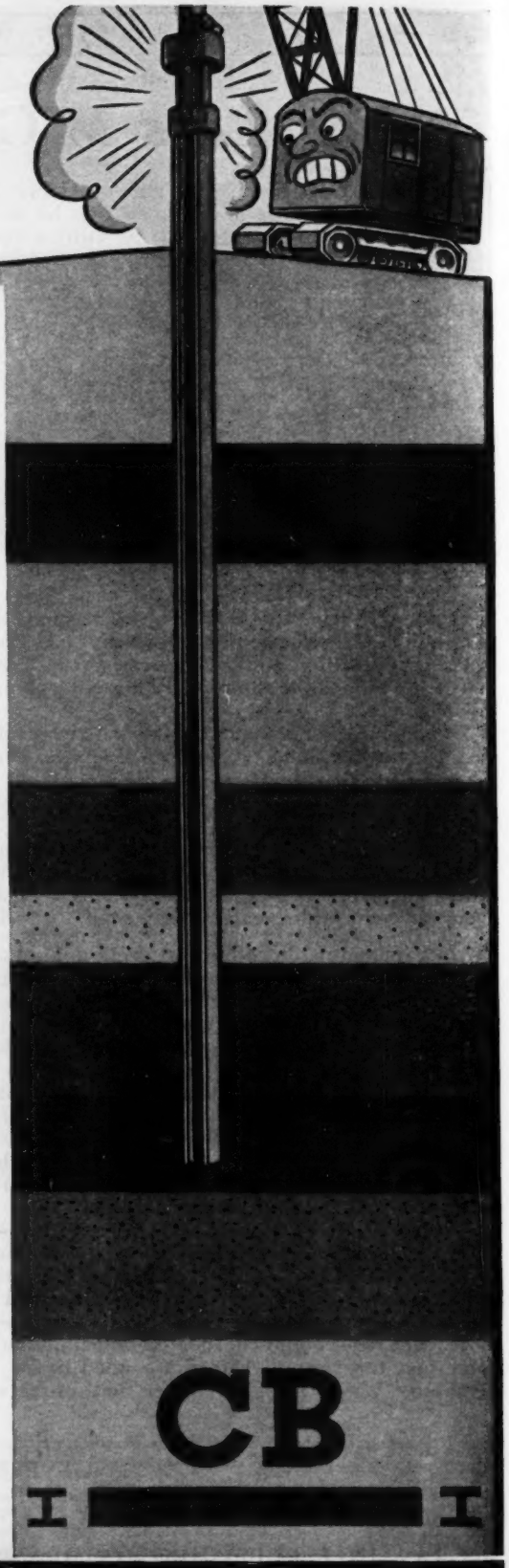
THEY'LL TAKE IT



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In The News:

THE MOLARE DAM on the Orba River in Italy failed on Aug. 13 with a large loss of life reported. Information as to the cause of failure is not available, but the whole region suffered from an abnormal storm, according to the Associated Press report. A brief description of the dam is given in the news pages of this issue.

AN ALLOTMENT of more than $2,000,000 has been made from WPA funds to the Corps of Engineers for flood-control work in five states in the south and central parts of the country.

HIGH WINDS AT HALETHORPE, MD., unroofed the Transportation Building, a structure put up in 1927 for the Baltimore & Ohio's Fair of the Iron Horse. Extensive damage was done to exhibits by the collapse of the walls and by the roof.

THE LAST GAP in the 66-mile levee encircling the southern end of Lake Okeechobee in Florida has been filled, thus bringing that $17,000,000 flood-control project another step toward completion. Some gaps remain to be closed in other sections.

THE LAST of the 25 footbridge cables for the Golden Gate Bridge was placed on Aug. 15. Each is 1 7/16 in. in diameter and 4,274 ft. long.

AS A FIRST STEP in a movement to obtain a more abundant supply of water for domestic purposes, Salt Lake City, Provo and Orem have voted to set up metropolitan water districts under an act recently passed by the Utah legislature.

PARKER DAM appears to be assured to the Southern Californians, the conference report on the Rivers and Harbors Bill which carries an amendment making the dam perfectly legal having been approved by the House of Representatives on Monday.

SIGNS OF BETTER TIMES are found in the increase in projects put forward for PWA financing on a loan-and-grant basis rather than as an outright gift in the form of a WPA project, with all the strings that are attached. More than 3,000 projects totaling $750,000,000 have been filed with the PWA.

FORT PECK DAM

The many and widely varied construction operations now in progress at Fort Peck, Mont., in driving the diversion tunnels for the Missouri River and in building the largest hydraulic-fill dam yet undertaken will be described in articles to be published next week—Aug. 29. The entire issue will be given over to a group of timely and authoritative articles.

In This Issue:

POWERFUL TIDES and frequent storms made construction of the south pier of the Golden Gate Bridge a most difficult problem. How it was accomplished in deep water 1,100 ft. offshore is described by Russell G. Cone, the resident engineer.

THIN SLABS made of brick grouted to metal lath have shown remarkably high strengths in tests conducted at New York.

JOHN F. STEVENS, in the second article on "Early Days at Panama," tells of the preparations made for construction operations on a scale never before attempted. His policy for obtaining efficient administration is set forth in succinct phrases.

WHEELER DAM on the Tennesse River is entering the final year of construction. Unusual elements of the work are reviewed in this issue.

THE LIFE OF LONG TIMBER TRESTLES on the Old Spanish Trail, built in 1916, has been extended by substituting concrete for timber decks. Load limitations called for an unusual slab design.

A TRESTLE-TYPE QUAY built of concrete at Parkeston, England, marks a further step away from the massive type of structure heretofore favored in Europe.

AS INSURANCE against further delay in driving the San Jacinto tunnel on the Colorado River Aqueduct, the water district has built two remote-control pumping stations at the shaft bottoms. They are unusual both in size and in completeness of the provisions against failure.

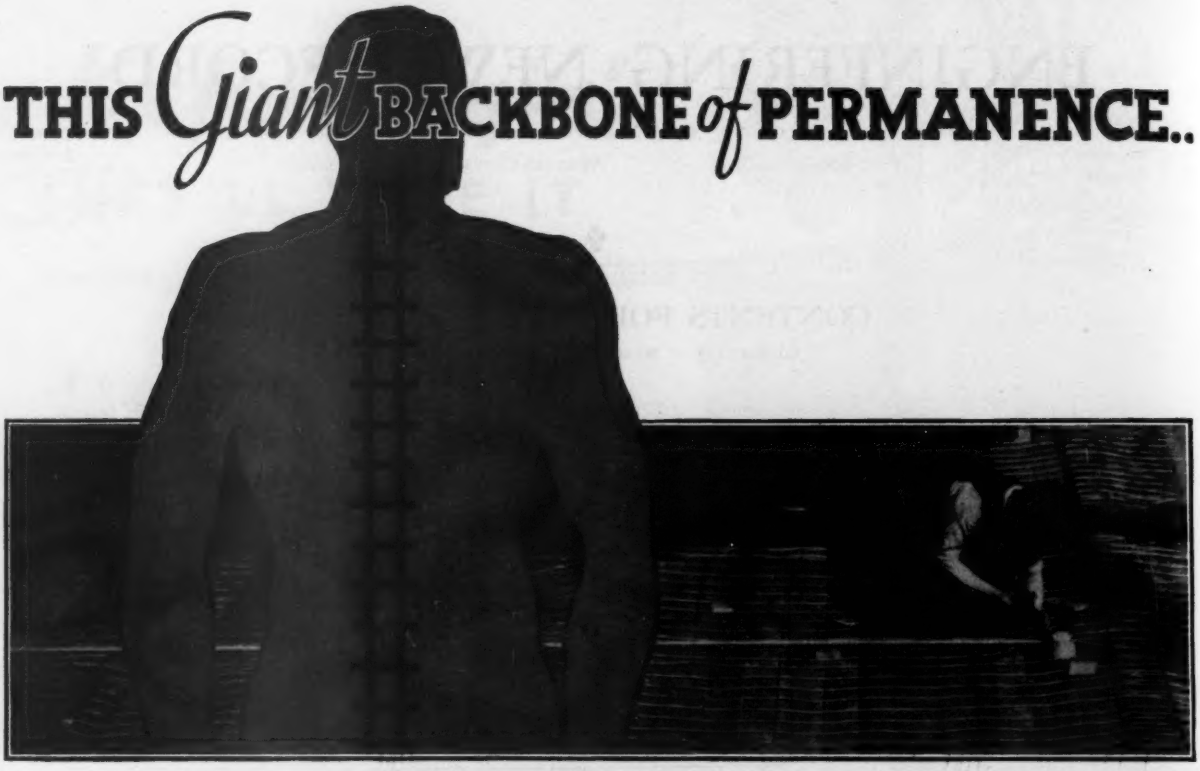
NATURE has joined hands with man in changing the character of long reaches of the Missouri River. How this has come about is reviewed by Roy N. Towl in telling of the river shortening that has taken place in the past century.

THE BOOK REVIEW SECTION for August contains an unusual contribution. Leon S. Moisseiff comments on a Russian report on the construction of the piers of the Saratov Bridge. The book indicates how Russia can be looked to as a future source of much information of value to engineers. Language difficulties now stand as a great barrier to fuller exchange of experiences.

Coming Articles:

THE REMARKABLE CRIB CONSTRUCTION employed in building the south cofferdam in the swift waters of the Columbia River at Bonneville is described in an article to be published soon.

THIS *Giant* BACKBONE *of* PERMANENCE..



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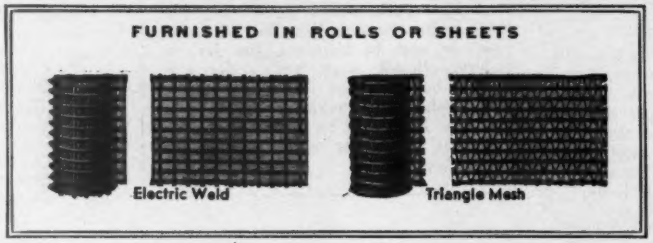

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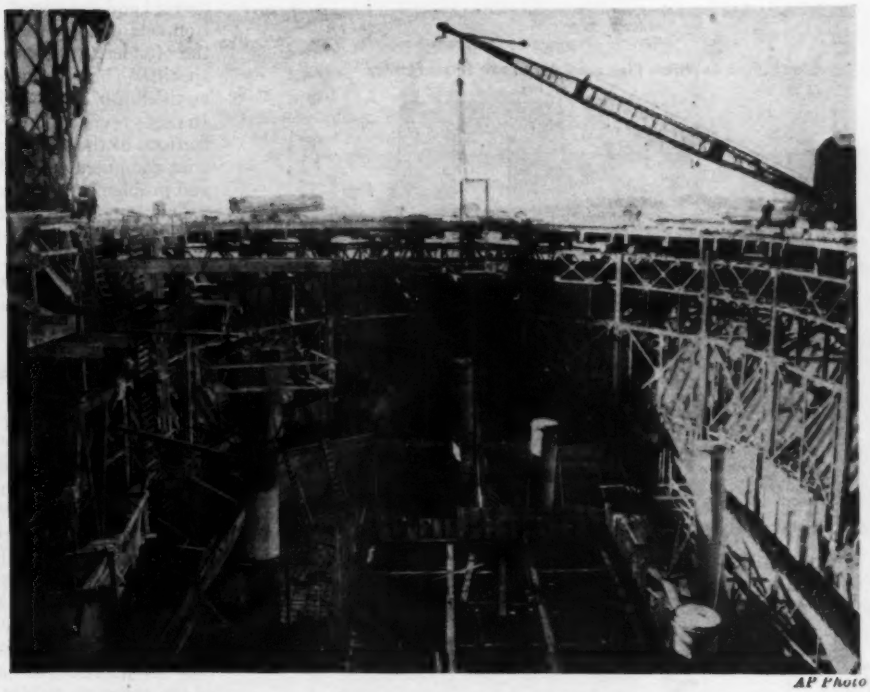


AP Photo

FIG. 1—INSIDE the unwatered fender ring, shafts of inspection wells extend through the seal concrete at El.—35; the shaft at the left has an airlock attached. At this time the originally planned use of a caisson for constructing the pier inside the fender had been abandoned, and the pier was concreted within forms in the dry.

Battling Storm and Tide in Founding Golden Gate Pier

Resourcefulness of contractor and engineers wins in long struggle against many odds, though caisson plan finally had to be given up

By Russell G. Cone

Resident Engineer, Golden Gate Bridge, San Francisco, Calif.

EXCEPTIONAL difficulties were overcome in building the south pier of the Golden Gate Bridge in deep water, powerful tidal currents and frequent violent storms. There was little precedent for the problems that had to be solved, and the successful outcome is testimony to the contractor's resourcefulness and perseverance.

The site of the pier is 1,100 ft. offshore at the narrowest point in the Golden Gate (the entrance from the Pacific Ocean to San Francisco Bay), where the tide sweeps with a velocity of 6.5 knots and where there is no protection from the full force of heavy seas and ocean storms. The bottom of the bay at this point is bare rock—a ledge of serpentine from which all traces of overburden have been swept away, lying 60 to 80 ft. below low water; the pier footing was to be carried to 100 ft. below low water. The rock was deemed amply capable of carrying the loads of the structure, provided sufficient confinement was assured and conservative unit loadings were used, but it afforded scant facilities for construction equipment and operations. Thus every proposed scheme for construction had to face not only the general problem of founding a pier in deep water on a rock ledge devoid of overburden but also had to deal with strong tidal currents daily, and occasionally the battering of heavy seas incidental to ocean exposure.

It was required by the specifications that, "The rock surface shall be exposed to permit thorough inspection, exploration and excavation, and the depositing of the concrete in the dry. The pier shall be constructed by the pneumatic process." A minimum penetration of 20 ft. into the rock ledge was believed to meet the condition as to confinement, and the pier was designed so that under full load, assuming uniform load distribution over the entire area, the pressure on the foundation would be moderate. As to method of construction, analysis of the problem indicated the essential requirement to be

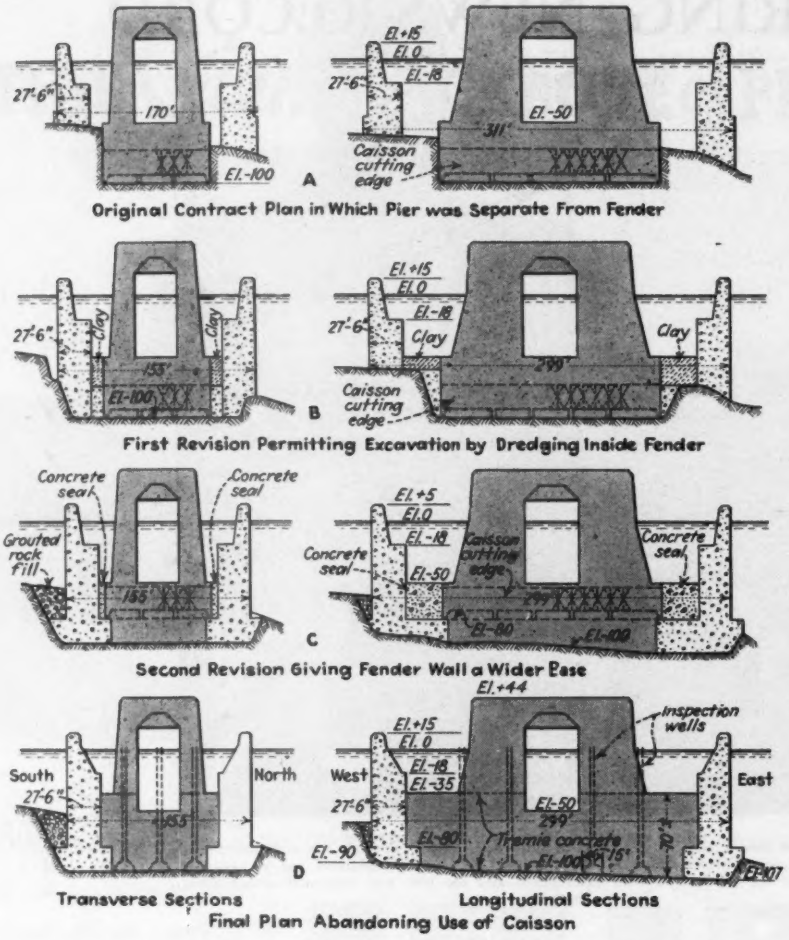


FIG. 2—DEVELOPMENT of the construction plan for the south Golden Gate Bridge pier in four successive stages.

sufficient protection of the pier site to permit excavating and leveling off a bearing surface 20 to 40 ft. down in the rock, and provision for inspection of the foundation bedrock as an assurance of its security.

The original design therefore contemplated the construction of a concrete fender wall 27½ ft. thick from its base support on the sloping rock surface to El. —18, and a thinner tapered wall above. This fender was to be 170x311 ft. outside, with rounded ends, and 110x247 ft. inside. Within this enclosure a pneumatic caisson 90x185 ft. in over-all plan dimensions, with rounded and pointed ends, was to be sunk as a base for the concrete pier superstructure, the latter to begin at about El. —50.

Contract for construction of the pier was awarded by the Golden Gate Bridge and Highway District, for whom the bridge is being built, to the Pacific Bridge Co. on Oct. 14, 1932, at a total price for pier and fender combined of $2,600,000. This contract was made on the basis of the original scheme developed and specified by the chief engineer of the district, which called for the construction of the fender wall in successive units by underwater methods and for pneumatic sinking of the pier base itself. As the work progressed, conditions made changes in the construction procedure necessary, and from time to time the original scheme was revised and developed. The final construction retained the method of constructing the fender wall about as originally specified, but discarded the pneumatic method for constructing the pier base. In these revisions the engineering organizations of the contractor and of the district combined to combat new difficulties and problems as they arose.

One important result of these changes was to eliminate the pier base as a separate unit and, in effect, to integrate the fender with the deep tremie concrete mass poured within the fender as supporting base for the pier.

Access trestle and guide tower

The use of floating equipment at the pier site for anything but dredging was precluded by rough water. The first step in construction was to provide access to the pier site by a trestle, which it was planned to continue around the pier site. A steel trestle was therefore built out from shore to the pier site; the deck of this first trestle was at El. +15. The original plan for trestle-bent footings was to drill holes in the rock slightly larger than the steel columns and, after insertion of the columns, to place concrete around them, but this plan was abandoned when no drills could be found that would clear the holes effectively as they were drilled.

A submarine bombing scheme then was developed, which consisted of dropping a small bomb on the rock at the pile location, driving it into the rock with a heavy follower, then firing it, and shattering the material with successive blasts of this

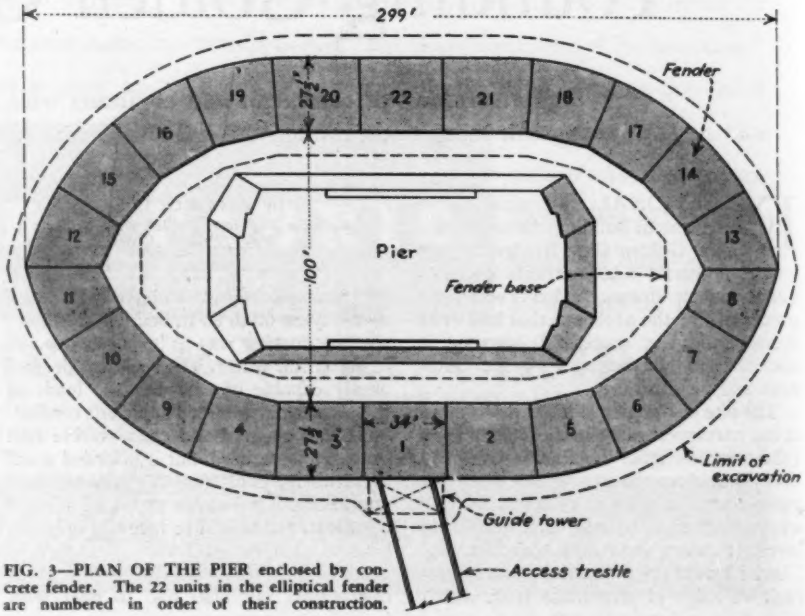


FIG. 3—PLAN OF THE PIER enclosed by concrete fender. The 22 units in the elliptical fender are numbered in order of their construction.

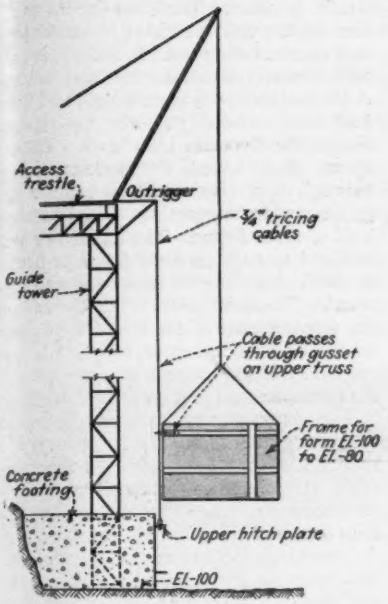


FIG. 4—ELEVATION showing method of lowering steel and timber frame of form for fender base. After placement by divers of concrete-weighted wood panels, similar forms were used for concreting between El. —100 and El. —80. Finally the wood panels were removed.

sort until it was possible to drive a steel tubular-pile footing. This method was successful. The steel tubes were driven into position, and the bottoms of the columns were inserted in them. After each bent was erected, the tubes were filled with concrete. Under this plan, trestle erection proceeded rapidly and was completed Oct. 19, 1933.

Just as the trestle was completed a 2,000-ton steamer ran through it 400 ft. offshore. The collision carried away six spans entirely, and because the trestle deck had been securely fastened together the impact of collision thrust the remaining portion of the trestle about 6 ft. inshore.

Wreckage of the demolished bents was removed by divers. The destroyed section was replaced by timber bents, to save the time required for getting steel bents fabricated.

The outshore bent of the access trestle was built in the form of a steel tower that weighed about 50 tons and was designed as a guide for lowering into place forms for the first unit of a concrete fender ring to be built around the pier site. This fender was an essential element of the original design; inside it a caisson was to be sunk after floating in, and carried down to final depth by compressed-air work.

The outer vertical face of the guide tower was provided with two 85-lb. rails down which the forms for the first section of the fender were to be lowered; forms for succeeding sections would then be lowered down similar rails on the leading face of the previously concreted section. The tower was supported in the same manner as the trestle bents. Four footing pipes were first driven into the rock in holes made by small pilot bombs; then the tower was lowered, and the legs were guided into the pipes by divers. Difficulty and hazard attended the placing of this 50-ton steel tower, which had a length of 115 ft., because of the force of tides and waves which swept in from the open sea. Entering the tower legs into the foundation pipes required great skill on the part of the four divers doing the work, as well as close coordination between these divers and the crew above water. Working periods were limited to slack water between ebb and flow of the tide. The tower was placed on the sloping south side of the pier excavation mentioned later; the lower or north legs were founded at El. —90 (about 10 ft. above the bottom of the pier excavation), and the upper or south legs at El. —70, on the adjacent sloping surface.

Several plans for the fender ring

Several methods for constructing the fender, an elliptical concrete wall around the pier site, as a means of protecting the pier during construction, were developed at different stages of the work. The original plan was to erect a concrete fender wall 30 ft. thick at the bottom, entirely around the pier site, and within this fender to build the pier base as a pneumatic caisson. The fender wall was to have been founded on the original surface of the rock, and when the enclosure was completed a pneumatic caisson was to have been sunk through a sand level-

FIG. 6—FENDER TRESTLE BENT ready for lowering. This bent is bracing for forms above El. —40. Note two centrally located vertical guides for form panels.

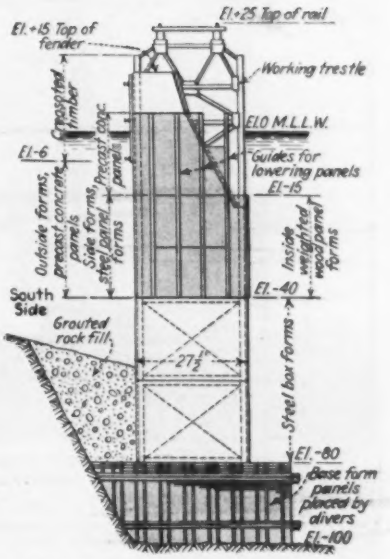


FIG. 5—ELEVATION showing the zones in which different types of fender forms were used.

ing fill placed inside the fender. The caisson was to have penetrated 20 ft. or more into the rock ledge, thus placing the pier bottom at El. —100.

This original plan of construction for pier and fender was revised, with the approval of the chief engineer, by the contractor's consulting engineers, Moran & Proctor, of New York, so that the excavation, except for final preparation of the bottom, could be done by open dredging instead of by use of the pneumatic caisson. Under this plan, on which construction started, the inside of the fender was to be at the bottom of the pier-excavation. (See second pair of sketches shown in Fig. 2).

Excavation at the pier site was started with a floating dredge coincident with construction of the access trestle. The water depth at the south or land side of the pier was 65 ft. and at the north side 85 ft. at the deepest point. The rock ledge was of such hardness that it could not be removed without blasting. A method of underwater blasting developed for the particular conditions met on this work was described in *Engineering News-Record*, July 27, 1933, p. 93. Briefly, it involved blasting with small pilot bombs until a sufficient depth of rock had been loosened so that a large bomb containing some 200 lb. of high explosive could be driven into the hole well below adjoining rock surface. A novel phase of this method was the driving of the large bomb into place by means of a 2,500-lb. hammer, after which the wire leads to the blasting cap in the bomb were recovered by a diver and carried to an electric blasting machine on the surface.

After blasting, the loose rock was excavated by a 5-cu.yd. bucket with specially reinforced manganese-steel teeth and lips. The great amount of wear on this bucket attested the hardness of the

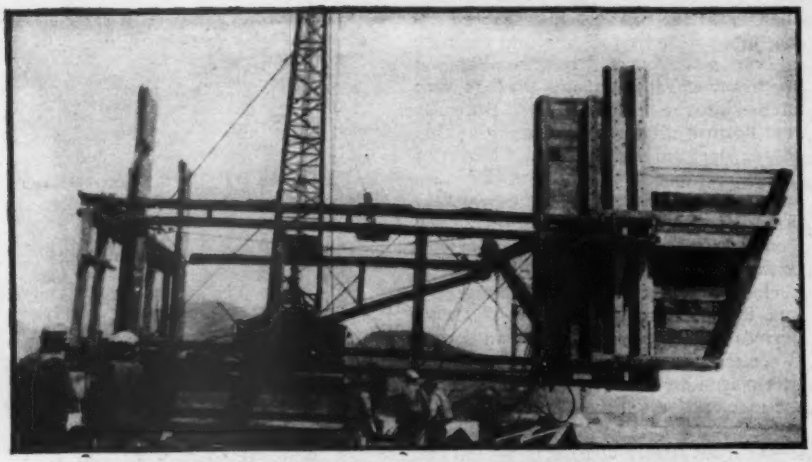


FIG. 7—FRAME FOR FOOTING FORM with some wood panels in place ready for lowering. Remainder of panels to complete form sides were placed by diver.

FIG. 8—DURING STORMS, waves broke through and over the deck of the access trestle. The caisson can be seen moored within the fender.

rock. In general, a depth of 15 ft. could be excavated after one layer of bombs had been fired 20 ft. below the rock surface. Successive layers of bombs were staggered so as to remove projecting high points. This program of excavation, carried down to El. —100, included the area on which the guide tower was to be erected.

Full-height pouring planned

The original method of fender construction, later modified materially, planned to place the concrete in one continuous pour for a height of about 80 ft. in each of the 22 separate units that were to comprise the fender ring. Each unit was to be 30 ft. square in plan, ultimately extending from El. —100 to El. +15, a total height of 115 ft. The forms for these units were to consist of a series of steel boxes each 20 ft. high, open top and bottom, fitted with jaw castings on one side to engage the guide rails on the face of the guide tower. The bottom of the first box form was carefully shaped to make a close fit with the bottom of the bay, as determined by very accurate soundings.

To insure a close fit between successive sections, it was planned to lower the first box until the top was just awash and then to erect a second 20-ft. section on top of the first. The two sections were to be fastened together by riveted splices of the columns in the corners. The assembled pair of units, each with jaw castings engaging the rails, was to be lowered until a third and subsequently a fourth section could be added, thus making a tier of sections fastened together. When the tier rested on the bottom, the topmost edge would have been at El. —20.

This program was followed up to the point where four sections (80 ft. of continuous forms) were suspended in engagement with the rails of the guide tower. The plan was that when this combined form had been rested on the bottom it would be filled with concrete by the tremie method up to El. —20 without interruption. After this first unit, 80 ft. high, had been completed, the same procedure of lowering successive boxes and riveting them together was to be followed for succeeding units until all 22 were in place, thus completing the fender. The point of note in this plan is that each individual unit was to have been concreted continuously for a height of 80 ft. before any concrete was placed in the next unit. Difficulties met in this plan will become apparent in the following.

After the legs of the guide tower had been entered into the pipes embedded in the rock foundation, they were concreted firmly in place. The steel form for the first fender unit, weighing about 40 tons, was successfully placed in the guide rails and lowered until its top was awash. Additional sections were added, and three had been riveted together as planned before the elements interfered. Then a storm that rolled tremendous waves through the Golden Gate caught the guide tower supporting this eccentric load of three forms. The tall tower was buffeted to such an extent that it began to oscillate about 6 ft. backward and forward. The oscillation evidently caused the displacement of the foundation pipes on which footings were supported, and on Oct. 31, 1933, the entire tower and the forms atached to it were carried away.

The contractor at once proceeded to recover guide tower and forms. No sooner had they been salvaged than another storm caused a repetition of the tremendous rollers sweeping in through the Gate, and this time all but 600 ft. of the access trestle was carried away. Coincident with the removal of the wreckage, the contractor's engineers began to develop plans for a new and stronger access trestle.

In reconstructing the trestle it was decided to use timber not only because of the saving in time by avoiding the delay necessary for fabrication of new steel bents, but also because the round timber piles offered less resistance to the strong tidal currents than had the steel sections used previously. Other improvements in design included raising the trestle deck height by 5 ft., so as to keep the stringers well above the tops of high waves, and guying the bents with steel cables in both directions. The reconstructed trestle deck was 25 ft. above mean lower low water. The new trestle was started Dec. 15, 1933, and was completed to the pier site March 8, 1934. The last three bents of the trestle adjacent to the guide tower were made of steel and were very rigidly braced both above and below water.

Failure of the guide tower had demonstrated the difficulties of supporting the fender on the sloping sides of the pier excavation and suggested the wisdom of having fender footings on a level surface at the same elevation as the pier bottom.

Accordingly, a modificaion of the fender design was developed, and the plan of construction was changed to meet it. Departing from the original plan for a continuous pour in each vertical unit, it now was decided to lay up the fender wall in courses about 20 ft. high. The courses were to consist of blocks about 30 ft. square corresponding in plan to the original 22 fender units. The start on the first course was to be made at the point where the first vertical unit had been started, and it was decided to include in this footing the columns of the guide tower. The base section of the first fender unit, therefore, was formed and concreted in two parts, an inshore and an outshore section.

As a part of this plan the area excavated to El. —100 was increased to per-

mit the entire fender ring to be supported on a level foundation at the same elevation as the bottom of the pier, instead of only the inner portion of the ring as was done at first. Also, under the modified plan, the fender units were to be built up to El. —60 around the entire elliptical ring before any appreciable amount of exposed wall was raised above that level. This is the plan that was finally carried to completion.

It was proposed that, after the fender ring had been closed at El. —60, the westerly end would be built up to its full height of El. +15, and then the steel framing over eight units at the east end above El. —60 would be temporarily removed to permit entry of the caisson into the fender ring. After the caisson had been floated into place the plan was to replace the steel framing on the east end, complete the concrete fender ring and then load and sink the caisson within the fender enclosure.

At this time, also, it was found from careful study of the stability of the fender sections under all weather conditions that, because of their greater height resulting from dredging the full fender area to El. —100, an increase in the base width of the fender would be necessary. In December, 1933, therefore, the base section of the fender ring was increased in thickness by a 10-ft. offset inward and by whatever outward offset would be necessary to carry the concrete up against the wall of the excavation within which the fender was built.

The inward offset of the fender base, with its top at El. —80, extended into the area that was to be covered by the caisson. In consequence the caisson could no longer be sunk down to the rock surface but would have to come to rest on the ledge of the fender base. It was contemplated that the space between the caisson and the inner face of the fender would be filled with concrete from El. —80 to —50, by tremie, to seal the joint in order to make it possible to hold the compressed air while gaining the foundation. Concrete piers were to be built within the fender area under the intersections of the caisson cross-walls, to assist in carrying the weight of the caisson until the working chamber could be sealed.

The excavation over the fender base area was to be carried to El. —100 in general, but to —105 at the east end of the fender and to —110 at the northeast sector, where the original rock surface dipped down in a narrow swale to about —95. Outside the fender a fill of grouted riprap was to be placed to fill the excavation in the rock.

FIG. 9—FENDER AND PIER completed and tower erection under way.

Final design for concrete forms

The revised plan for placing concrete in the fender ring involved building a considerably larger surface of formwork under water. Because most of the steel boxes planned for use in the original concreting scheme had been fabricated, the contractor prepared to utilize as many of them as possible. Accordingly, these boxes were used between El. —80 and El. —40.

The larger cross-section of footings for units under the revised plan called for the development of a lighter form. Therefore, for that portion of the fender between El. —100 and El. —80 each form was built as a relatively light wood and steel frame lowered into position on tricing lines, two to each form (fastened as shown in Fig. 4), which served to guide the forms to their proper positions. The frame alone offered a minimum of resistance to tidal currents as it was lowered. Once the frame was in place on the botton, fastened to the adjoining units, the sides were built up with wooden panels about 5 ft. wide. These panels were weighted with concrete blocks, to overcome buoyancy, and were placed by divers using a fastening adapted to quick manipulation under water. All of the wooden panels and the principal members of the steel frame were stripped and reused after the concrete had set.

The bottom form for the pioneer unit was placed in two sections. The first of these encompassed the legs of the guide tower; later the first steel box was lowered and rested upon the bottom form, after which concreting of the remainder of the base and the steel box was made as a continuous pour. On all the remaining sections the first or bottom steel box was concreted integrally with the base block.

The second steel box, constituting the form for the fender wall between El. —60 and El. —40, was concreted integrally with an adjoining box, so that the second course of the wall was built up of blocks 30x60 ft. in plan and 20 ft. high.

Above El. —40 an entirely different plan was used, and the wall was built of blocks approximately 30x60 ft. in plan and 25 ft. high. The bents and bracing in the trestle over the fender site were so designed that they later served as guides for form panels. This skeleton steel frame offered a minimum of resistance to the current during construction of the ring below El. —60, and was thoroughly braced so that in building that part of the fender ring above El. —40 two 20-ft. sections of the panel forms could be erected simultaneously with safety. The forms were designed to withstand a hori-

zontal pressure of 130 lb. per sq.ft. Above El. —40 form panels of three kinds were used: steel, weighted timber and precast concrete. The latter were made 6 in. thick and of widths to fit the spaces between the vertical guides. Precast concrete panels were particularly useful in forming the outside of the fender where a smooth concrete face was required.

The entire fender wall was firmly bonded together with keys between adjoining units and by staggering the vertical joints. In addition, the top portion of the wall above El. —2 was heavily reinforced with steel bars. These tie the tops of the units together and develop arch action in case the structure is rammed by a ship. Above El. —40 enough vertical reinforcing is used so that each unit would stand securely as a vertical cantilever in resisting both wave and current forces.

Fender seal and caisson

After the first concrete was poured in the pioneer unit on March 31, 1934, progress in the fender ring proceeded according to schedule, to the point where the eastern end of the ring was concreted to El. —40, and the remainder of the fender wall had been brought up to El. +15, the ultimate height. This was in accord with the original plan to leave the eastern end open, to permit the floating in of the caisson.

An important change was made after the final plan of fender construction had been adopted. It was decided to abandon the purpose of exposing the foundation bedrock within the caisson, and instead to place a tremie concrete seal within the fender up to El. —65. The base of the caisson was to be set on the top of this seal concrete instead of on the fender base ledge at —80 as previously intended. However, in order that the foundation rock could be inspected (and, if necessary, further excavation done) a series of eight inspection wells 6 ft. in diameter was to be provided in the concrete seal, each ending in a 15-ft. steel hemisphere resting on the rock surface. These shafts could then be entered from the caisson working chamber under the protection of compressed air and the foundation rock examined. This decision was reached in June, 1934.

Results of the dredging operations had indicated that the material under the entire pier area was uniform. Hence it was felt that the area made accessible by the eight inspection wells would give ample characteristic evidence of the nature of the foundation rock. In case inspection indicated any necessity for going deeper with the pier foundation it still would be possible, by excavating in the inspection chambers under air pressure and using the seal concrete as the deck of the working area, to carry the pier footing to a lower level.

When the entire fender ring had been brought up to El. —40 and a few units at the west end had been continued to El. +15, the effect of currents and wave action on the bottom was so greatly diminished that divers were able to prepare the surface of the bottom at the pier site for the tremie seal. The area to be covered was too great to attempt a single continuous pour, and therefore it was divided into seven sections, each 30x90 ft. in plan. Wooden forms, similar to those used in the construction of the fender bases, were designed for three of these sections and were placed by divers. Details of these forms were such as to permit the removal of all wood used as forms in the tremie seal. The first tremie sections were carried up to El. —65.

On Oct. 8, 1934, with all skeleton steel bents removed from the east end of the fender, the caisson was towed to the site and safely moored within the fender enclosure. Preparations immediately were begun to close the east end of the fender. Before this could be done, however, a violent storm arose, and the surging of the caisson within the fender enclosure caused by wave action made it impossible to hold it firmly in place with mooring lines. It battered the steelwork and concrete of the fender with such force as to threaten to wreck itself within the fender enclosure. Several of the fender frame members were badly bent, and the inner face of the concrete was gouged.

Because wrecking of the caisson within the fender at this time would endanger the rest of the work and seriously delay completion, the contractor secured permission to remove the caisson at once and to abandon that part of the construction plan that involved its use. Accordingly, the caisson was removed, and closure of the east end of the fender wall was begun immediately.

The fender ring was completed on Oct. 28, and by Nov. 4 the tremie blanket had been raised to El. —65. In lieu of using the caisson, the contractor planned to pump out the fender enclosure, using the fender wall as a cofferdam. To do this, it was considered wise to add more concrete to the seal, raising its upper surface to El. —35. This additional concrete was put in in seven units, overlapping construction joints in lower portions of the seal and increasing the thickness over the shelf of the fender base. The several changes made in the seal and the shape of the pier shaft above El. —35 served to distribute the load over the base of the entire fender in addition to the base of the pier. The original bearing area of the pier, 16,000 sq.ft., was thus increased to 38,000 sq.ft.

The greatest pressure on the pier from the superstructure is 84,000 tons. As originally designed, the pier foundation was independent from that of the fender wall, and the pier alone weighed 130,000 tons. This gave a uniform pressure of 13.6 tons per sq.ft. and, under extreme loading conditions of the bridge, a maximum pressure of 20 tons.

The bridge was designed for an earthquake equivalent to a horizontal force of 10 per cent of its weight. The most severe combination of the loading and this earthquake force would have then resulted in a maximum pressure of 26 tons per sq.ft.

In the pier as built its total weight, including the fender wall, is 300,000 tons, but the base area has been increased from 16,000 to 38,000 sq.ft. The average pressure on the base has thus been reduced from 13.6 tons per sq.ft. to 10 tons, and the edge pressures, under extreme loading, have been similarly decreased.

On Nov. 27, 1934, the pier area within the fender wall was unwatered; the wall was found to be remarkably tight, and very little pumping was needed to keep the bottom dry. The shafts of the eight inspection wells were fitted with air locks, to permit of access to the rock surface under air pressure. Examination of the foundation within these wells then was made by the engineers and by Dr. Andrew C. Lawson, consulting geologist. In addition, pressure tests were made by hydraulic jacks braced against the roof formed by the hemispherical chambers. The conclusion was that the foundation rock was adequate in all respects, and accordingly the eight inspection chambers and shafts were filled with concrete.

Within the open cofferdam formed by the fender ring and the concrete seal, forms for the pier proper were built. On Jan. 3, 1935, the pier had been concreted to its final height, El. +44. Quantities involved in the south pier construction were as follows:

Concrete in fender wall, cu.yd.	76,300
Concrete in seal and pier, cu.yd.	70,000
Reinforcing steel, tons	647.9
Rock excavation for pier and fender, cu.yd.	45,000

The cost of the pier to the district was $2,950,000, including (in addition to the original contract price) the sum of $350,000 paid under a supplementary agreement for increased excavation and quantities.

All underwater concrete was deposited through tremies. In general, each position of the tremie was expected to deliver to an area of 900 sq.ft. A concreting rate of 100 cu.yd. per hour was common. To test the uniformity of tremie concrete at various distances from the tremie pipe, cores were taken with a diamond drill. These cores showed equal distribution of coarse aggregate as far as 35 ft. from the tremie pipe and showed a compression strength of more than 4,000 lb. per sq.in. in 28 days.

Concrete was batched at the plant of the Pacific Coast Aggregates Co. near the bridge site, and was delivered by trucks that mixed in transit. All concrete placed in fender and pier contained 7 sacks of cement (1¼ bbl.) per cubic yard.

High-silica cement was selected, and the results justified this choice because there was decided advantage in the notable workability of the concrete where large tremie pours were made. Tests indicate that the cement will show a high degree of resistance to sea water.

The bridge is being built by the Golden

Gate Bridge and Highway District. Joseph B. Strauss is chief engineer, Clifford E. Paine is principal assistant engineer, and the writer is resident engineer. The consulting engineers are O. H. Ammann, Leon S. Moisseiff and Charles Derleth, Jr. The management of the Golden Gate Bridge and Highway District is vested in a board of directors representing the six counties of the District. William P. Filmer is president of the board, and James Reed is manager.

Officers of the Pacific Bridge Co., contractors for the south pier, are as follows: the late C. F. Swigert, president; Philip S. Hart, vice-president; and W. G. Swigert, secretary-treasurer. The work in the field for the contractor was under the immediate direction of Philip S. Hart and Jack Graham, superintendent. Chris Hansen was chief diver.

Thin Slab of Brick and Metal Lath Shows High Strength and Low Cost

TESTS recently made in New York City of reinforced brick slabs, consisting of one course of brick laid on metal lath and grouted, showed unusual carrying capacity and low cost for this type of construction. On a 36-in. span a load of 1,605 lb. per sq.ft. was carried without failure and with only about ⅛-in. deflection. The cost, including necessary steel beams, which contributed about a third of the total, is indicated to be some 29c. per sq.ft.

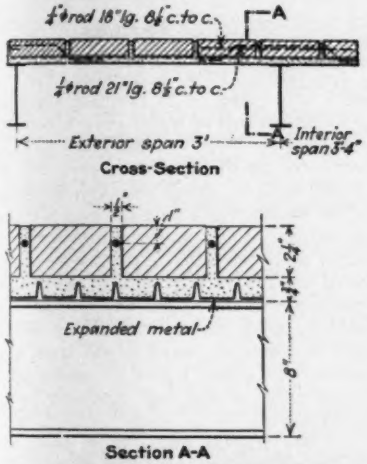


FIG. 1—REINFORCED BRICK SLAB in which metal lath serves as forms during construction as well as for reinforcing.

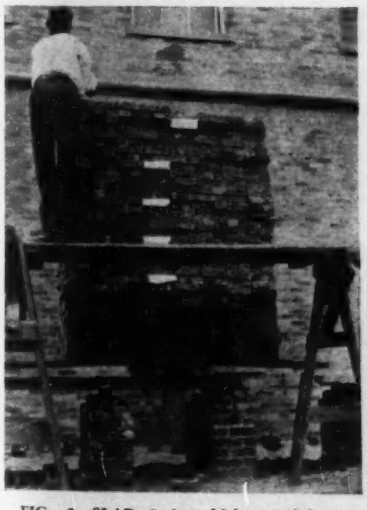


FIG. 2—SLAB 3 in. thick sustaining a 1,605-lb. per sq.ft. load at the third-points of a 36-in. span.

Three slabs, 29 in. wide and 9 ft. 4 in. long, were constructed and tested on three lines of 8 in. 6½-lb. steel beams, as shown in the accompanying illustration. The slabs were designed by J. H. Hansen and Odd Albert of the Brick Manufacturers Association of New York, to demonstrate a sturdy economical type of floor for small houses. They were constructed by laying the metal lath across the three supporting beams, spreading a 1-in. bed of stiff cement mortar on the lath and laying the brick flat and dry on this bed. Negative reinforcement of ¼-in. bars spaced 4½ in. on centers was used over the supports, every second bar being bent down to take the shear. As a final operation, a cement mortar grout was poured into the joints. The total weight of the slabs was 35.75 lb. per sq.ft. They were 3¼ in. thick.

A brief review of the several tests follows, as reported by Mr. Albert. In the majority of tests the load was supplied simultaneously to all three spans on a plank platform that transmitted the load to the brick slab through six 3x3-in. timbers placed at the third-points of each span. The test of the first slab was stopped after the load reached 11,502 lb., or 510 lb. per sq.ft., equal to 680 lb. per sq.ft. uniformly distributed. The total deflection at this loading was found to be 0.0235 in., about one-fifth of the allowable deflection of 0.111 in., based on a deflection of 1/360th of the span. When the load was removed after three weeks, no cracks or damage to the slab were noticeable.

In testing slab No. 2 the load was applied at the third-points of the end span. When a load of 11,628 lb., or 1,605 lb. per sq.ft., equal to 2,140 lb. per sq.ft. uniformly distributed, had been applied, the test had to be stopped because there was no more loading material available. The deflection was estimated to be less than ⅛ in.

Two tests were made on slab No. 3. In the first test the loading was applied in the middle span only, at the third-points. At a load of 5,168 lb., or 642 lb. per sq.ft., the test was stopped. A deflection of 0.0115 was recorded.

In the second test the slab was allowed to remain under the 642 lb. per sq.ft. load overnight, after which the load was carried to 8,748 lb., or 1,085 lb. per sq.ft. Deflection at that load was about 0.08 in. Failure occurred suddenly without warning at a load of 1,120 lb. per sq.ft. No crushed brick or cracks could be seen. The metal lath did not break and exhibited a perfect bond after failure. It was a typical shear failure just beyond the ends of the negative reinforcement. No rods were exposed, although the outside curved face of the hooks of the negative steel could be seen in the crack. The slab was designed for uniformly distributed loading.

FIG. 3—TYPICAL FAILURE of three-span slab under a load of 1,120 lb. per sq.ft. applied at the third-points of the 40-in. center span. Breaks occur at ends of negative steel used over the supports.

Fort Peck Wins Safety Award

During the last half of the year 1934 the Fort Peck District of the Army Engineers made the best safety record of any of the engineer districts in Group 4. Group 4 includes those districts engaged on river work in each of which over 250,000 man-hours of work are performed monthly by government employees.

The table below gives the record of all districts in the group and indicates the basis of the award made by Maj. Gen. E. M. Markham, chief of engineers:

District	Man-Hours Worked	Injuries, No Lost Time	Lost-Time Injuries	Fatalities	Total Days Lost Time
Fort Peck	1,877,621	59	30	0	440
Vicksburg	3,578,908	230	78	2	13,148
St. Louis	1,805,345	91	36	3	18,562
Kansas City	1,761,456	141	50	1	7,180
Memphis	4,309,527	206	125	4	30,176
2nd New Orleans	3,153,917	353	133	3	20,204

Watertight Pump Chambers for a Flooding Tunnel

San Jacinto tunnel, drowned out twice to a height of over 600 ft. in shafts, is equipped for recurrence of flooding by sealed pump chambers located at shaft bottoms and operated from shaft tops

FIG. 1—A WET HEADING at Potrero shaft at a time when the inflow was 1,300 g.p.m. Estimates based on the rate at which water rose in the shaft indicate that the maximum inflow exceeded 4,000 g.p.m.

IN THE 241 MILES of aqueduct being built by the Metropolitan Water District of Southern California to bring Colorado River water to the Los Angeles area, the limiting factor in the date of completion is the 13-mile tunnel under a shoulder of Mt. San Jacinto. Topography dictates that an 8-mile section of this tunnel must be driven from two headings, one advancing westward from the bottom of Cabazon shaft and one eastward from Potrero shaft. From the Cabazon shaft westward, 5,500 ft. already has been driven, and the work is proceeding through broken waterbearing zones. It is a curious anomaly that although the greater portion of the aqueduct passes through territory of extreme aridity, work on this critical section of the job, between Cabazon and Potrero shafts, has been delayed by a heavy inflow of water.

The sudden inflows were heavy enough to drown out the contractor's equipment several times and to delay the work so much that from July, 1934, to February, 1935, the contractor did not make any advance in the Potrero east heading. The district then took over the work (*ENR*, Feb. 21, 1935, p. 298) and began the installation of large-capacity pump units at tunnel level both in Potrero and Cabazon shafts. Major interest attaches to the novel installation at the bottom of the 800-ft. Potrero shaft for the reason that space economy, concentration of power, automatic control equipment and special provision for ventilation combine to make it an unprecedented installation. These features are described in the following, which also gives an outline of the general situation in the wet eastern end of the San Jacinto tunnel between Cabazon and Potrero shafts.

San Jacinto tunnel lies about 90 miles east of Los Angeles (see map, *ENR*, July 26, 1934, p. 98). Potrero shaft is 3 miles east of its west portal. By the end of last year the shaft had been sunk to its full depth of 796 ft., and headings had been driven a short distance in both directions—160 ft. east and 447 ft. west. Progress in the east heading had been slow because water was encountered. In fact, on the last day of June work in that heading was temporarily shut down because of the quantity of inflow, which reached 3 sec.-ft. (1,350 g.p.m.).

Repeated floodings

On July 1, 1934, at a time when no work was going on in the east heading, a sudden inrush of water occurred there sufficient to flood both headings quickly and come up the shaft to within 165 ft. of the surface. After this first flooding of the tunnel, for a time the inflow came in surges. Later more uniform flows of as much as 4,000 g.p.m. were indicated by the rate at which the water level rose in the shaft, whose diameter is 15 ft. inside the concrete lining. Even after unwatering, many weeks later, the inflow was 3,000 g.p.m. or more, and for months it did not diminish very materially.

Of the several pump units installed by the contractor, one was a specially designed thirteen-stage turbine pump driven by a 700-hp. motor and rated to deliver 2,600 g.p.m. against a head of 900 ft. A 12-in. Kingsbury plate bearing designed for a thrust of 15 tons was built in the motor to carry the weight of water and pump when operating under full head. This pump unit, weighing about 50 tons when equipped with a 12-in. discharge line, 800 ft. long, was supported on steel I-beam across the top of the shaft by clamps around the pipe.

An incident in the contractor's difficulties was the breaking of this discharge pipe line, dropping the big pump to tunnel level and promptly flooding out the shaft. This occurred when unwatering had progressed to within 50 ft. of the tunnel. In the flood which followed this accident, water was reported to have risen in the shaft at a rate exceeding a foot per minute.

Novel pump-chamber design

When the district took over the work early this year, an entirely new plan

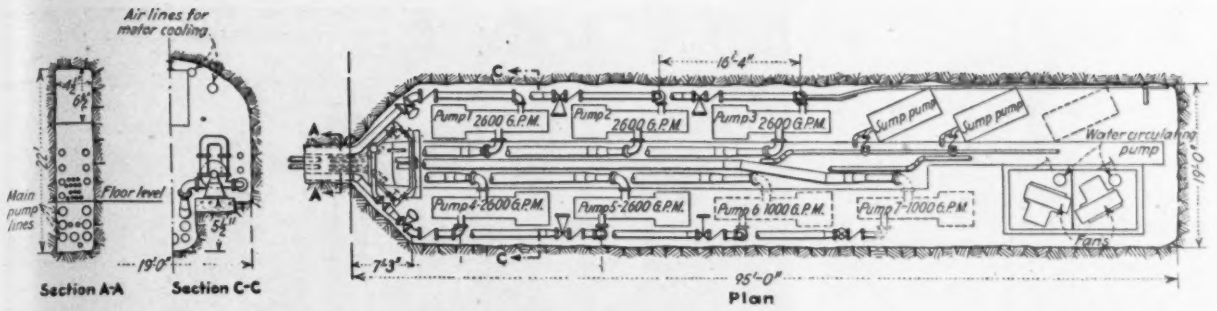


FIG. 2—DETAILS of pump chamber layout at the bottom of Potrero shaft.

was adopted for removal of the inflowing water. Previously, pumps of the sinker type had been used. Henceforth, district engineers decided, the plan would be to use horizontal centrifugal pumps permanently installed in pump chambers at tunnel level, at the bottom of Potrero and Cabazon shafts.

The pump chamber at Potrero shaft required the greater care in design because it was decided so to construct it that it could operate continuously at full capacity even if the tunnel should be flooded and the 800-ft. shaft should entirely fill with water. This introduced problems in ventilation, cooling, automatic control and pumping out seepage, and evidently the success of the plan as a whole depended on the absolute reliability of every detail of the equipment installed.

In general, the pump chamber consists of an excavation in the rock at right angles to the tunnel, much like an adit drifted off to one side. In this case, however, where the adit connects with the main tunnel, it has a smaller section, like the neck of a bottle. The pump chamber is 110 ft. long, including the 16-ft. length of the constricted section. In the full section the chamber is 19 ft. wide and 22 ft. high at the center; in the constricted section it is 4½x22 ft. In the lower part of this constricted section were placed the numerous pipe lines, conduits, etc., and in the upper part there was a doorway for access to the chamber. A concrete plug then was poured around these openings so that the inner chamber could be sealed off from the tunnel. The design of the door and the plug as a whole was such that it will be able to resist the water pressure resultant from a head of 803 ft., which would obtain at shaft bottom if the shaft filled.

The plan was to equip this pump chamber so that in the event of any sudden flood the pumps could function automatically with no manual control closer than ground surface, 800 ft. above. This entailed, in addition to the main units for pumping water up the shaft, equipment for recirculating within the chamber air that would cool the motors driving the pumps, a water-circulation system for cooling the air, a pumping system for removing seepage, and the automatic control mechanisms that would enable these several systems to function automatically or to give such indications in the control room at the top of the shaft that manual control from that point would be perfectly feasible.

Access doors

Access through the plug into the pump chamber is by means of a 4½x6½-ft. opening fitted with a door heavy enough to withstand an 803-ft. water head. The door is made up of welded I-beams; its sill is 25 ft. back from the tunnel center line and 9 ft. above the tunnel floor. At this height there is considerable capacity in the tunnel before the level of the pump chamber entrance would be reached by any sudden inrush of water. Within the large door is a smaller one, 24x31 in. in size, to give workmen access to the chamber. The large door has a swung weight of 5¼ tons and ordinarily will be kept bolted shut; it will be needed only when machinery is to be moved in or out. The smaller access door has no means for fastening it in the closed position other than a counterweight; this feature is a safeguard against anyone being entrapped in the chamber and insures closure of the door in case the pumpman is forced to leave hastily. Rubber belting in both door frames insures watertightness.

A 12-in. I-beam suspended from the roof extends the full length of the chamber and is provided with a chain-block traveler for lifting pumps, motors, etc. Near the door the I-beam is over a track at sill level on which equipment can be moved through the doorway.

Each of the seven main pump units in the chamber has its separate suction pipe through the concrete plug. The discharge lines likewise go through the plug separately, but on the outside they are combined before being led up the shaft in two 14-, one 12- and two 8-in. discharge columns. These discharge pipes are hung from the top of the shaft, but concentration of weight is relieved by clamps at intervals of about 100 ft., where supports are grouted into the walls of the shaft. Guides in the form of steel bands at 30-ft. intervals also were put in, to prevent any tendency to buckle. Because of the uniform temperature of air and water, very little expansion effect is expected.

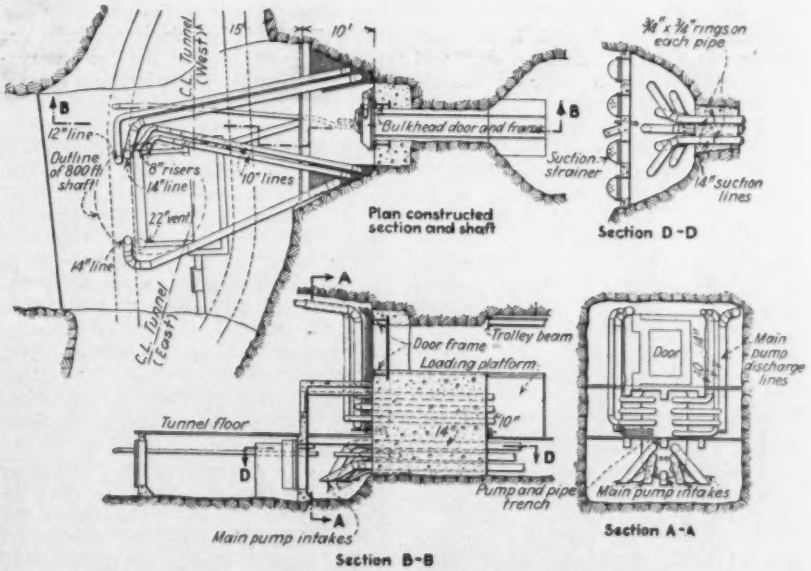


FIG. 3—DETAILS OF PUMP CHAMBER PLUG and connections between pump chamber and shaft.

The concrete plug in the constricted section contains seven 14-in. suction pipes, seven 10-in. discharge lines, a 6-in. discharge from the sump pump, and 6-in. suction and discharge from the circulating pumps. In addition, there are several small air lines. Each unit has its separate conduit for electrical power from the surface, making fourteen 3-in. cable conduits through the plug. As the larger pipes were placed in the bottom of the plug, the piping has a minimum of bends in passing from the central trench or sump in the pump chamber through the plug and into the shaft. Around each pipe, where it passes through the plug, are welded $\frac{3}{4}$x$\frac{3}{4}$-in. angles bent into the form of a ring as cutoffs, to prevent seepage of water along the pipes. Reinforcing bars were embedded in the concrete of the plug.

Equipment installed

The Potrero pump chamber houses seven main pump units, five of 2,600-g.p.m. capacity and two of 1,000-g.p.m. capacity. The head in each case is 850 ft. The five larger pumps are four-stage horizontal units, direct-connected to 700-hp. pipe-ventilated motors. The two smaller pumps, of the same type, have 300-hp. motors. The ventilation system used for cooling the motors and the pump chamber is of the closed-circuit type; that is, the ventilator ducts from each motor lead into common supply and return ducts, and the air is cooled and recirculated by being passed over the fins of a cold-water circulating system. Air flow in this system is effected by fans operated by 30-hp. motors. Each of the two blower systems has a capacity of 20,000 cu.ft. per minute against 6 in. of water pressure; duplicate ventilation systems afford protection against the risk that some minor mechanical accident or defect might shut down the entire plant.

Should the air flow fail, a check damper in the fan discharge duct will close and actuate a mercury switch, which automatically stops one blower-cooler unit and starts the other. Cooling water is available from the sump of the main tunnel at from 65 to 70 deg. F. This makes it possible to furnish an air supply in the ventilating system of 80 to 85 deg. F. Provision is made for introducing 2,000 cu.ft. per minute of cooled air from the ventilating system into the pump chamber. The circulating pumps, like the blowers, are in duplicate; each water-circulating pump is rated at 400 g.p.m. against a 60-ft. head and is driven by a 10-hp. motor.

All pipe joints in the chamber are welded except where the pipes make connection with the pumps. Likewise, all pipes are tested to 1,000 lb. per sq.in., approximately twice the service head.

The chamber is unlined. To take care of the possibility that there would be seepage through the rock or leakage from the pumping systems, two duplex pumps were installed; these are operated by 60-hp. pipe-ventilated motors and are rated at 195 g.p.m. each, under a head of 803 ft. Space for a third pump of the same size is provided.

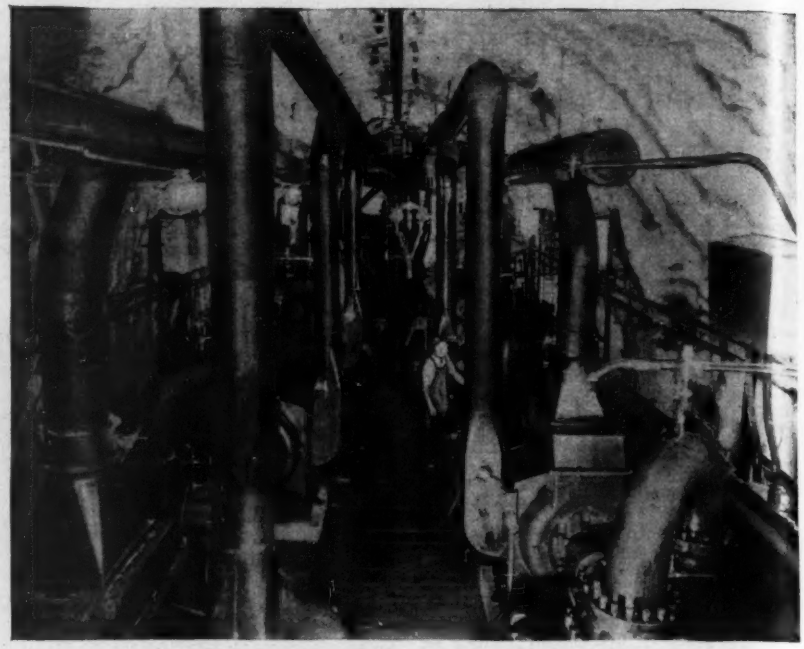


FIG. 4—PUMP INSTALLATION at bottom of Potrero shaft, looking from doorway into watertight pump chamber.

A vacuum pump operated by a 2-hp. motor is so connected that it can be used for priming any of the centrifugal pumps. This requires manual operation of valves for starting each main unit successfully. Priming would be unnecessary in an emergency in which the tunnel was flooded. All interconnections that would be a convenience are provided; discharge lines from the main pumps are cross-connected so that operation of valves can fill any line from any other; water discharged from the main pumps can be substituted for water pumped expressly for the cooling system, and the main pump intake is divided into two chambers so that one can be shut off to permit clearing out muck accumulations. The suction intakes are protected by screens, and baffles arranged like louvers are installed ahead of the screens to limit the inflow of mud.

The ducts in which cooling air is carried to the motors are made of 14-gage metal; diameters decrease from 20 in. in the main headers to 12 in. at the motors. Supplementing the air-circulation system is a pair of 3-in. pipes that bring fresh air from the top of the shaft. This is for renewing oxygen supply, to make the chamber livable during such test runs or other operation as may be carried on with someone in the chamber. The blower for this fresh-air system is at the surface.

The control mechanism on all electrical units in the chamber is made automatic as far as possible, and the operating condition is recorded in a control room at the top of the shaft. An alarm sounds in this room when any operation is performed automatically in the underground chamber.

Cabazon shaft

Water inflow into the tunnel heading reached through Cabazon shaft, the easterly shaft, has not been as serious as at Potrero shaft. Yet it was recognized that the water difficulties here might increase as the heading advances, and for this reason it was considered desirable to build a pump chamber at tunnel level that would give the same assurance in the Cabazon headings as now obtains at Potrero. The lesser depth at Cabazon made it more economical to provide a separate shaft through which access to the pump chamber would be possible at all times, and fewer precautionary measures were therefore necessary. The installation is similar in many respects to that of Potrero, but the design is much simplified by the fact that it will be possible at all times to have an operator in the pump chamber.

The Cabazon pump chamber is 75 ft. long, 14 ft. wide and 22 ft. high. The plug between the chamber and the tunnel will be very similar to that at Potrero already described. Forced-air cooling of the main motors will be used, although in this case the motors operating the air-cooling system are on the surface, and 22-in. air ducts are carried through the auxiliary shaft. Two separate air systems and two separate water-cooling pump systems are provided.

At Cabazon six main pumping units are installed. Four have a capacity of 2,500 g.p.m. each, at 275-ft. head, and

two are rated at 1,000 g.p.m. A valved pipe connection is made from the suction of one 1,000-g.p.m. pump to the sump within the chamber, to handle seepage from the tunnel. The discharge of the four larger pumps is carried in two 14-in. pipes through the auxiliary shaft, that of the smaller pumps through two 8-in. columns in the main shaft.

The construction of the plug in the constricted section between chamber and tunnel was somewhat simplified by the fact that electrical conduits and some of the pipes go to the surface through the auxiliary shaft. However, the two-in-one door for access between chamber and shaft and the main pump intake are quite the same as at the Potrero installation.

The initial installation of pumping units at both Cabazon and Potrero shafts was completed and the pumps were given a preliminary tryout in the early part of June, 1935. Whether they ever will be called upon for capacity service remains to be seen, but at least the work of advancing the tunnel headings now has the assurance of large-capacity pumping units ready for instant service if heavy inflows occur suddenly.

When these emergency pumping installations were completed, the water being pumped out of Potrero shaft amounted to about 4,600 g.p.m., of which 2,000 g.p.m. was in the west heading, which is downgrade from the shaft. At Cabazon the inflow total 4,200 g.p.m., practically all of which was coming from the west or downhill heading.

The work is being done by The Metropolitan Water District of Southern California, of which F. E. Weymouth is general manager and chief engineer, J. L. Burkholder assistant general manager in charge of construction, Julian Hinds assistant chief engineer, and C. R. Rankin engineer in charge of San Jacinto tunnel construction. Design of the pumping stations was under the direction of J. M. Gaylord, chief electrical engineer.

An Engineer's Recollections—X

EARLY DAYS AT PANAMA

BY JOHN F. STEVENS

Consulting Engineer, Baltimore, Md.

Civilian Engineers Prepare for Construction

Initial efforts concentrated on the erection of proper shelter for the construction forces, provision of adequate water supply and sewage-disposal facilities, and the creation of an efficient commissary department

EDITOR'S INTRODUCTION—John F. Stevens served as chief engineer of the Isthmian Canal Commission from 1905-1907, as was noted in the introduction to the previous article (*ENR*, Aug. 15, 1935, p. 216). In that period his staff, with the notable exception of Colonel Gorgas, was made up largely of civilian engineers. In 1907, when Mr. Stevens resigned, President Roosevelt decided that in seeking a new chief engineer he would choose one familiar with govenment routine. Consequently, Col. George W. Goethals was named chief engineer and took with him to Panama other army engineers for key positions.

The natural result of this change was that much of the credit for the successful completion of the undertaking has gone to the army engineers who succeeded Mr. Stevens. This Mr. Stevens recognizes as inevitable, but as the years have gone by he has become impressed with the fact that if he does not speak out in the interest of the civilian engineers who functioned so effectively in obscurity during his régime there will be none left to speak for them. In the following article and one to be published subsequently Mr. Stevens brings out in an effective way the notable contribution that those engineers made to the canal construction. —EDITOR

THE PANAMA CANAL, regarded as a historical topic, may rightly be considered by the layman to be a rather trite subject, but to engineers there are some facts in connection with its planning and construction which should be of interest to the profession, and which are entitled to a place in written history. The important part which civilian engineers played in that monumental work has never been set forth in any comprehensive, authentic narrative. The writer believes that he is more qualified to do this than is any other living person, owing to the circumstance of his having had active official connection with the great project during a critical period in its history. And such a narrative, dealing with facts, written without prejudice and with strict impartiality toward all parties, should be an important contribution to the knowledge of the profession.

The handicaps that confronted these engineers in the early part of 1905 were many and serious. The most formidable one was unquestionably yellow fever. While the situation was largely psychological, there was a grave danger which could not be ignored, as it imperiled the very life of the vast project. This was the situation which I encountered when I took up the duties of chief engineer. Without going into details, it can be justly asserted that it was the immediate, wholehearted support which the engineering department gave at a critical time and continued to give to Colonel Gorgas and his efficient corps of assistants that enabled the sanitary department to eliminate the deadlly disease and make it possible for Americans to live in safety and work on the Isthmus.

In any comments which I may make upon the condition of affairs existing at that time, no adverse reflection whatever is intended upon the ability of my predecessor. I had known Mr. Wallace for many years as a high-class engineer, and I was not long in deciding why and how the unhappy situation that existed had developed. The inefficient Walker Commission, the utter lack of responsibility definitely located, the endeavor to decide and act upon the most trivial matters at a distance of 2,000 miles by a body of men who were apparently unable to agree with each other or with anybody else, would have been a sufficient reason for a partial or even a total failure, no matter who had been chief engineer. It would have required an official fight to make progress, for, while the new commission was an improvement on the old one, I think that Mr. Wallace had lost faith in any commission, that he felt that it was a fight, or resignation, and that he chose the latter course. The situation called for vigorous independent action by the chief engineer, which it got at once, receiving full approval of the commission at all times.

I found no organization worthy of the name; no answerable head who could delegate authority and exact responsibility; no cooperation existing between what might charitably be called the departments—quite the contrary, and a disposition (not shared by the engineers) to believe that the construction of a successful canal at Panama was a very dubious project. Faith in the undertaking could only be secured by prompt practical action and an utter indifference to any threatened danger.

At once the formation of an organization was undertaken, one capable of expansion as work increased in volume and variety, and flexible enough to provide for contingencies. There was already in service a lot of good engineering personnel, enough to form the nucleus of an organization. All it needed in most cases was faith in a leader whom it could trust and follow with confidence. The personnel was enlarged and strengthened from time to time, and it was not long before it worked as a unit.

Ample authority delegated

The various classes of the work, as far as they could then be determined, were segregated, and selection was made of what appeared to be the best-fitted men to head the subdivisions of the engineering department, making these as few as practicable. One general policy was put in force, and that policy is the only one that leads to efficient administration: to give the official ample authority and hold him strictly responsible for results. Such a policy encourages initiative, which is a most valuable asset to an engineer. A maxim was laid down and came to be thoroughly understood, that to make a failure certain in my view an engineer should do nothing of his own volition but should "pass the buck."

I have stated in general terms how the engineers in civil life were organized for the work of building the canal. It would be invidious to attempt to list names, as omissions might be innocently made, and I would regret to cause heartburnings by ignoring worthy men. I can confidently assert that to my knowledge and belief no abler force of engineers was ever entrusted with responsibility or more intelligently or faithfully met it. I am not picturing them as "supermen," for they were not. They were simply representative of the best type of educated Americans, and no higher type of manhood exists; they only needed to be shown the way and to be provided with proper means to enable them to get results, and they did so, with an eye single to the interests of the great project. With respect to supermen, it has probably been my misfortune, but I have never chanced to meet any of them.

I will note some of the major operations which the engineering organization carried out, and as its duties and powers became so comprehensive by force of circumstances its different sections were designated as departments. It will of course be understood that many indispensable adjuncts other than those of a purely engineering technical nature were planned, installed and put into service as necessary to put the construction house in order before any real effective work on the canal proper could proceed.

Housing and feeding the workers

The gathering, selection, housing and feeding of all labor, skilled, unskilled and clerical, was the province of the department of labor and quarters. To secure an ample supply of the first, and to ensure its quality, agencies were established in a number of our larger industrial cities, where the personnel was carefully selected and forwarded to the Canal Zone. All common labor at first was made up of negroes from the British and French islands of the Caribbean Sea, as being inured to a tropical climate. This plan was later somewhat modified by bringing over some 9,000 Gallegos from the Biscayan provinces of Spain, to counteract a hazy notion that the blacks had gotten into their heads that they held the whiphand in common labor. The move succeeded beyond my hopes. After three months an ample supply of labor of all kinds was in hand, and no undue delay occurred in filling all calls for the different classes of workers.

This department, through the Panama Railroad Commissary, greatly enlarged, which it managed, furnished all food and the countless variety of different articles of merchandise required by canal employees. The commissary was really developed into an immense department store, and it handled about every article of human needs. No profit from sales was exacted, and overhead was cut to the bone. A system of cash coupons was introduced, and no individual book accounts were kept; as a consequence, supplies were sold at comparatively low prices. I paid the same prices as did all of the other employees, and the best quality of Chicago dressed meats, eggs and other perishable foods cost me about 65 per cent of what I paid while living in Chicago within five miles of the stockyards. The hotels and eating houses, some 40 of them, served meals as good as those served in such places in the States, at about 70 per cent of the cost of the latter.

A combination ice, cold-storage and laundry plant was built at Cristobal, modern in every particular. In 1907 it had a daily output of 80 tons of ice, 25,000 loaves of bread, and laundry for at least 3,000 white people. From the moment that meats, etc., left the packing houses in Chicago until they were in the hands of the consumers along the Canal Zone, they were under refrigeration every moment. A supply train of refrigerator cars left the commissary every morning at 4 o'clock, and never later than 9 a.m. every hotel, eating house and family had its daily supplies, including ice, properly wrapped and tagged, clear through to La Boca, now Balboa.

As fast as houses and barracks were ready, the department furnished them, installed the proper occupants and exercised supervision over them. There were many other functions entrusted to this department which space does not permit describing. The system worked wonderfully well, with the result that we had a family of thousands of contented workers.

From housing to shop buildings

To provide living quarters for the many thousands of employees of different classes was a heavy task for the engineering organization, but it was accomplished speedily, and well. The department of building construction was created, charged with the work of building and keeping in repair all structures of whatever nature that were required on the Canal Zone. Designed by its own architects, there quickly began to appear not segregated buildings but towns, some of them really small cities. There were many structures in various stages of decrepitude, souvenirs of the old French régime, left on the line. Those of them that were worth while were reconditioned, modernized and made fit for human occupancy. In addition, hundreds of new buildings were erected—dwelling houses, barracks, churches, school houses, police stations and jails, hotels and eating houses, hospitals, club houses, post offices, machine shops all the structures required for railroad operation. The number and variety of buildings necessary seemed to be endless. I do not know how many such new buildings were erected but as a conservative estimate I would say at least 5,000.

In additon to all this class of construction, the department built ocean piers, warehouses, platforms, etc. For months it carried on its payrolls some 12,000 men, including the negro laborers, and in eighteen months used about 90,000,000 bd.-ft. of lumber, mostly brought from Puget Sound. It necessarily dealt in large figures. I recollect that requisitions for wire screening totaling more than $90,000 passed over my desk. All buildings in which human beings lived or worked were thoroughly screened—windows, doors and verandas. They were equipped with baths, modern sanitary fixtures and electricity; in fact, except for being of a light type of wooden construction, they were fairly typical of American smaller homes, the dwelling houses usually being of the bungalow type. My policy was to build only for ten-year life, as I estimated that number of years would see the completion of the canal, after which at least 90 per cent of the buildings would be no longer needed and would be destroyed, as was done.

One of the most imposing structures

built was the Tivoli Hotel, on a commanding site at Ancon. It was built and furnished in less than six weeks. At one time, directly and indirectly nearly a thousand men were employed on its construction. It is there yet, more modernized and added to in some small features, and is one of the best tourist hotels in the tropics.

I moved the headquarters of the engineering organization from Panama City, where it was occupying the buildings of the old Delesseps régime, to a new town which I had built at Culebra, a point about midway of the length of the famous cut of the same name. A capacious administration building, with offices for the heads of the various departments, was built, and also many structures of the various classes that were necessary to house the employees who carried on the work in the immediate vicinity, especially that of administration. An extensive telephone system was installed, covering the entire Canal Zone, Panama and Colon. Sitting at my desk in the administration building, I could contact without undue delay every office, shop, steamshovel, switch shanty, etc., along the whole line. I think that there must have been from four to five thousand inhabitants in, or within a radius of a couple of miles, of the new town by the middle of 1907.

Another new town, Empire, was created not far from Culebra, where were built and equipped the large machine shops that erected and kept the steam shovels in repair. There was not a half mile along the line of the canal that did not give constant visual evidence of the tremendous activities of the building department.

Streets, water and sewerage

Closely allied with the work of building construction was that of the department of municipal engineering. It planned and laid out the new towns, graded and macadamized the streets, built sidewalks, found sources of potable water supply, laid mains and house connections, installed sewage disposal plants, and transformed what had been jungle wastes into attractive and healthful residential locations. At Colon a large earth dam was built some miles back in the hills, forming a reservoir from which a 12-in. cast-iron main carried the water by gravity to Colon and Cristobal, with sufficient head to throw it above the tops of the highest buildings. In both cities mains were laid covering the entire areas, and connections were made with every house, office or shop.

These two cities are built on a coral reef, and the natural elevation of the surface is less than 3 ft. above the level of the sea; consequently, the sewerage problem was a serious one. It was solved by building a large underground concrete-lined reservoir centrally located, into which the sewers discharged their contents. Duplicate electric pumps were installed, which pumped the sewage through a discharge pipe far out into the bay back of the cities. It was a well-conceived and executed project.

Panama City had no water supply except from shallow wells located throughout the city, into which sewage naturally seeped. Besides creating an abominable nuisance, the wells were choice breeding spots for mosquitos, particularly the deadly stegomyia, the yellow fever carrier. A concrete dam was built across a mountain stream 12 miles from the city, and from its reservoir the water flowed by gravity through a large cast-iron main to a concrete distributing reservoir built on Ancon hill, from which it was carried by gravity through mains to all parts of the city. House connections with venturi meters were installed, and the old wells were filled up with earth.

A complete modern sewerage system was built, discharging into the bay, where the heavy tides carried the sewage away. Some miles of the principal streets were torn up, and vitrified brick, brought from Peoria, Ill., was laid on a substantial concrete foundation. Other less important streets were macadamized.

These works built by the engineers at Colon and Panama City did not constitute merely improvements; they effected a rebirth into decency of two of the filthiest pest holes in the world. Both cities were made entirely free from tropical fevers, are clean, healthful and practically free from mosquitos and house flies, an agreeable contrast to many of the cities and towns in the States. After our Panama water supply was in operation, an expert from Washington reported that only three or four of our home cities' water supplies equaled it in purity.

Providing construction equipment

The department of power and machinery was one of immense importance and imposed vast responsibilities upon its officials. The great bulk of a construction plant, tools and machinery, such as never before had been gotten together in the history of the world, was planned, specified largely in detail, requisitioned, purchased and delivered on the work in record time. It consisted of almost every mechanical device which judgment and practical experience indicated was necessary and best adapted to do quickly and economically the vast and intricate work that lay ahead of the engineers, and the distance of the fabricating plants demanded that every item must be of the best quality.

Specifications for all of the larger classes of machinery, such as locomotives, cars, steam shovels, compressors, etc., were made by the department. Cast steel was substituted for cast iron wherever practicable, copper for iron boiler tubes, and a like standard of excellence was set up for the entire list of requirements, which in number were almost inconceivable. As samples of quantities purchased on single orders I may mention 125 locomotives, 75 steam shovels and hundreds of cars. All of the larger machines were shipped knocked down and were assembled and tested in the shops that had been built and equipped for their reception. Track material, hand tools of every description for all classes of work—the lists were too long and varied even to attempt to summarize—had to be obtained in the least possible time.

Some of the old French floating and land equipment was reconditioned and found serviceable in the smaller operations; but 99 per cent of the equipment used in canal construction was new, and of the immense amount provided during my time as chief engineer, every item of it, as far as I could learn, was well adapted to the purpose intended.

Watching weather and earthquakes

There was the department of meteorology and river hydraulics, charged with the duty of gaging the streams, especially the Chagres, and of giving prompt notice of approaching floods. It also had charge of the seismograph, which was located at Panama City. Light tremors of earthquakes were recorded, but those of any degree of intensity were apparently long distances away. A daily weather report covered temperature, winds, rainfall and hours of daylight. Any unusual phenomena were duly recorded.

My relations with the commission sitting in Washington were very harmonious. Three of the seven members were army engineers, retired, as I remember, and one was a rear-admiral of the navy. None of the members except the chairman came to the Isthmus, and he only for three brief visits.

Theoretically, the commission was supposed to supervise my work. Practically, it did nothing of the kind. It never ordered or even suggested in a single instance my line of procedure. It only knew of what we were doing from brief reports that I made from time to time, but at no stated periods, and these reports were always quickly approved. The members rightly assumed at the time that it was a one-man job, and they further knew (what I was well assured of) that I had the full backing of the President, with the knowledge and acquiescence of the Secretary, in whose charge the execution of the project was committed.

I have given a résumé of how some of the adjuncts created were necessary to provide a solid workable foundation upon which the actual construction of the canal could proceed. This work was done by and wholly under the supervision of civilian engineers during 1905-1907. Their practical service in the technics of projecting and executing the work that came under their charge as members of the engineering organization will be treated in a later article.

Wheeler Dam Construction Enters Final Year

Review of construction methods and progress in excavating 550,000 cu.yd. of rock and placing 650,000 cu.yd. of concrete in building dam 1¼ miles long on the Tennessee River

THE construction of Wheeler Dam on the Tennessee River, at the head of the lake formed by Wilson Dam 15½ miles downstream, has progressed to the point where it appears that this $23,000,000 project will be completed by September, 1936. With an over-all length of about 6,400 ft., this dam will be 1,900 ft. longer than Wilson Dam and 1,340 ft. longer than the Dnieper River hydro-electric and navigation undertaking in Russia.

General plans for Wheeler Dam were outlined in *ENR*, May 11, 1933. From the south bank, a non-overflow section extends 180 ft. to the powerhouse structure, 613 ft. long. Beyond the powerhouse is a non-overflow section, 177 ft. long, then a trashway 45 ft. long. Next comes a 495-ft., non-overflow section connecting to a 2,700-ft. spillway. Between the latter and a navigation-lock structure at the north end is a third non-overflow section, 1,737 ft. long, with a 45-ft. trashway in the end next to the lock. Between the 60x300-ft. lock and the north bank is a fourth non-overflow section, 270 ft. long, closing a gap in which there is space for an ultimate 110x600-ft. lock.

Designs for the 60x300-ft. lock at the north end of the dam were prepared by the Corps of Engineers, U.S.A. The construction of that unit was completed under the direction of that organization in 1934 (*ENR*, Aug. 17, 1933). The rest of the dam, including the powerhouse, was designed by the United States Bureau of Reclamation, and is being constructed by force account by the Tennessee Valley Authority.

General plan of construction

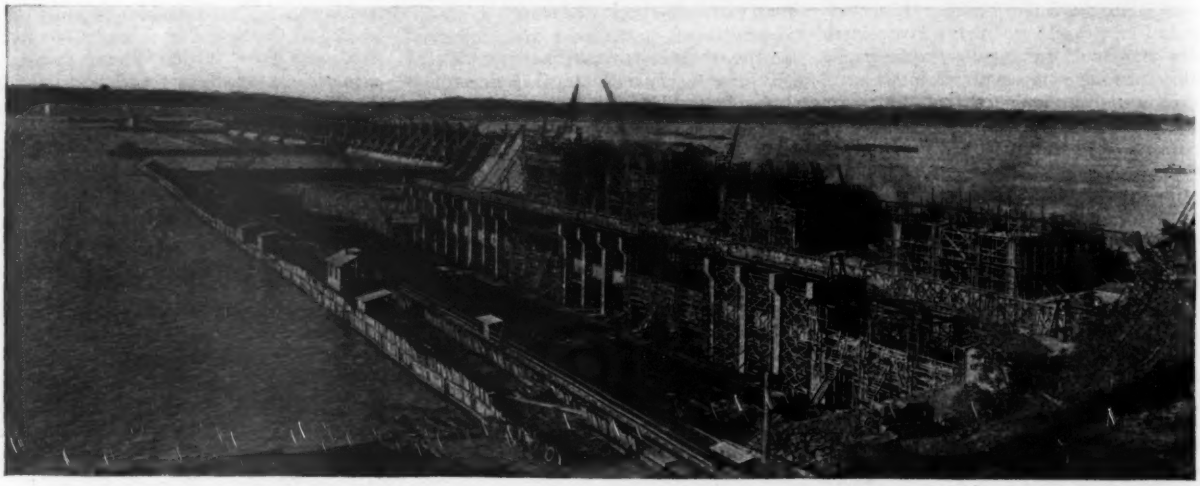
Construction plans for the project provide that the powerhouse and the non-overflow sections at that end first be built in a cofferdam extending offshore 1,425 ft. Thereafter four additional cofferdams, built successively from the first, were to unwater the site. These were to be in order 1,238, 1,147, 1,100 and 1,004 ft. in length. The work was thus to be conducted in five successive stages extending from the south bank, with no two adjacent cofferdams to be closed for any considerable period.

This general plan has been followed with substantial exactness. The second cofferdam was built as soon as the rock foundation for the powerhouse was prepared in the first one; as rock excavation in the second cofferdam was approaching completion, the third cofferdam was unwatered. These two cofferdams, together with part of the fourth, include the entire spillway section, which is built in alternate 15-ft. and 30-ft. blocks.

To provide ample capacity to carry floods across the job, 25 of the 30-ft. blocks are first poured to a height of about 1 ft. above the normal level of the pond of the Wilson Dam, and 36 of the 30-ft. blocks are poured to a height of about 8 ft. above that level, while the 15-ft. blocks between them are continued to full height to permit construction of the roadway crossing the top of the dam, which will be in service during the latter part of the job, to provide access to the last cofferdam area.

The non-overflow section extending from the spillway to the navigation lock, occupying part of the fourth and all of the fifth sections of the cofferdams, will be built to full height. Before these cofferdams are placed to close the stream, intakes for six waterwheels ultimately contemplated in the powerhouse will be available to carry flows up to ordinary floods. Meanwhile the downstream portions of the second and third cofferdams will be removed. Floods in excess of the capacity of the powerhouse intakes will overtop the upstream second and third cofferdams and may then be handled through the 61 30-ft. openings left temporarily in the spillway section. After the work is finished in the fourth and fifth cofferdams, the 30-ft. openings will be closed from floating mixer plants during low flows of the river. This closure work is to be done in the summer of 1936, between April and November, when high stages are exceptionally rare. In case floods occur in excess of the capacity of the powerhouse intakes, ample capacity will be available to divert the surplus flow through the temporary openings in the spillway structure.

This general plan of handling construction was based largely on the limited variation in the stage of the river due to the existence of the pond created by Wilson Dam. Except during floods, the water level at the site remains practically constant. Extreme floods may produce a height 4.5 ft. above the normal pond level at El. 505.06. Restriction of the 6,400-ft. stream width by the construction of the navigation lock and of the first three cofferdams has not caused any serious increase in velocities



WHEELER DAM, 6,400 ft. long, is being built in a series of five cofferdams built progressively out from the south shore at the head of the pond formed by the Wilson Dam crossing the Tennessee River 15½ miles downstream.

at normal stages in the 2,200-ft. opening, which will be occupied by the fourth and fifth cofferdams. These two closing sections also will be placed during the 1935 summer and fall low flows, so that difficulties in constructing and maintaining them due to swift water are not expected.

Transportation

Wheeler Dam construction operations were based on water transportation for the delivery of all materials and supplies, except light shipments that might be brought in by truck over local highways extending to the site. Imported shipments are brought by rail to a dock adjacent to Wilson Dam, where they are loaded on barges and towed to the job.

Sand and gravel for the 650,000 cu.yd. of concrete required in building the dam and powerhouse are obtained by dredging 35 to 50 miles downstream from Wilson Dam. Towboats bring barges from the dredge through three locks, two below and one in Wilson Dam. Cement is supplied by several mills, which ship by rail to a point below Wilson Dam for trans-shipment by barges to the project.

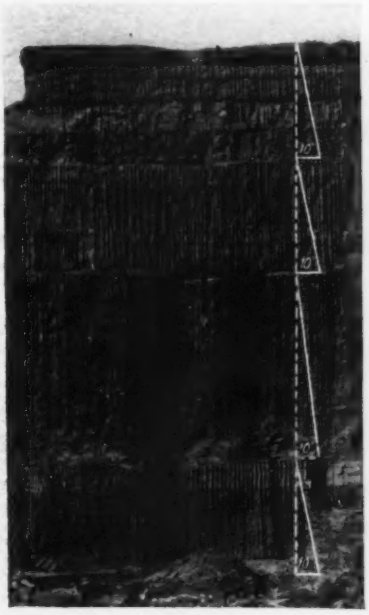
Experience with these methods of delivery has proved entirely satisfactory. No difficulties have been presented in floating any of the heavy construction equipment from the railhead to and into the cofferdams. Plans have been made also to handle all of the heavy waterwheel and electrical machinery for the powerhouse in this manner, by means of 100-ton stiff-leg derricks, one located at Wilson Dam and one at Wheeler Dam, both to remain there permanently.

Excavation of rock foundation

At the site of Wheeler Dam the Tennessee River is confined between two rock cliffs, ledge rock extending entirely across the bed of the stream without overburden. The formation is an alternating series of nearly horizontal layers of pure limestone and a cherty, siliceous rock, the latter occurring in much thicker strata than the former. Most of the few vertical joints are confined to one stratum. There are occasional cleavages, however, extending down through several layers of rock.

Numerous small cavernous fissures have been uncovered, but these have been of no consequence, except two in the foundation of the draft tubes. Such caverns and the limited number of solution channels found are readily filled with concrete or grout. An entirely satisfactory foundation is thus obtained.

Original estimates were that 550,000 cu.yd. of rock would have to be removed to prepare the foundation for the dam and to excavate deep enough to provide properly for the intakes and tailrace of the powerhouse. Present indications are that this total may be increased to around 570,000 cu.yd. Some of the spoil has been used in the construction of the cofferdams and in building up a flat area along the south bank for construction plant buildings. The rest has been wasted in upstream areas where it will not interfere with navigation or with operations of the project.



LINE DRILLING prevented rock from breaking beyond boundaries planned for excavation for dam and powerhouse emplacements. White line indicates, exaggeratedly, arrangement of drill cuts to preserve vertical face of pits.

On account of the nature of the rock, exceptional care has been exercised in the methods used in all excavation work. Outside the heavy cut required to obtain the necessary depth for the substructure of the powerhouse, most of the excavation has been comparatively shallow. Just enough of the weathered top strata has been removed to get down to solid ledges. This has varied from 10 to 15 ft. over most of the site outside the powerhouse area.

Excavation for the powerhouse structure extended to a depth of 50 to 57 ft. below the existing streambed. After considering various methods of drilling and shooting, the conclusion was reached that it was quite desirable to avoid any blasts close to the face of the deep cuts in which the power units are to be placed. A method of line drilling to the exact shape was accordingly developed.

A fleet of twelve wagon drills was installed for this purpose and to put down the holes required for blasting the rest of the excavation. In the line-drilling to the contours, these drills operated in sets of three to five on sectional steel track carried by portable timber runways. These drills were fitted with 2¼-in. bits on 18-ft. steel. With them holes were put on the line desired on 4½-in. centers to a depth of 15 ft.

As it was necessary to take out the material in three to four lifts to get the full depth, a plan was adopted to obtain practically a vertical face where the line drilling was done, to compensate for the clearance required by the drill when set up against the wall formed in the preceding lift. By tilting slightly the track carrying the drills, the latter made holes extending in 10 in. from the vertical at the bottom of each lift. When the next lift was taken out, the same off-vertical holes were drilled. As a result, the finished face had a series of narrow steps in it, with the top and bottom practically in a vertical line.

In drilling and shooting the remainder of the rock to be removed, no blast holes were put down within 30 ft. of the line-drilled faces. The nature of the material is such that careful loading broke the rock out to the line drilling with no shattering of the face of the excavation. Some potshots had to be used to break up large pieces between the line-drilled face and the closest blasts.

With this method the deep excavation in the stratified rock was made without any overbreakage. The saving in concrete thus obtained much more than offset the cost of the line drilling over other methods of getting the same results. But the undisturbed foundation face was even of more importance. In fact, this method worked out so well on the deep excavation that it was adopted for all face cuts, even as shallow as 6 ft., in stripping the foundation for the sections of the dam proper.

Grouting of foundation

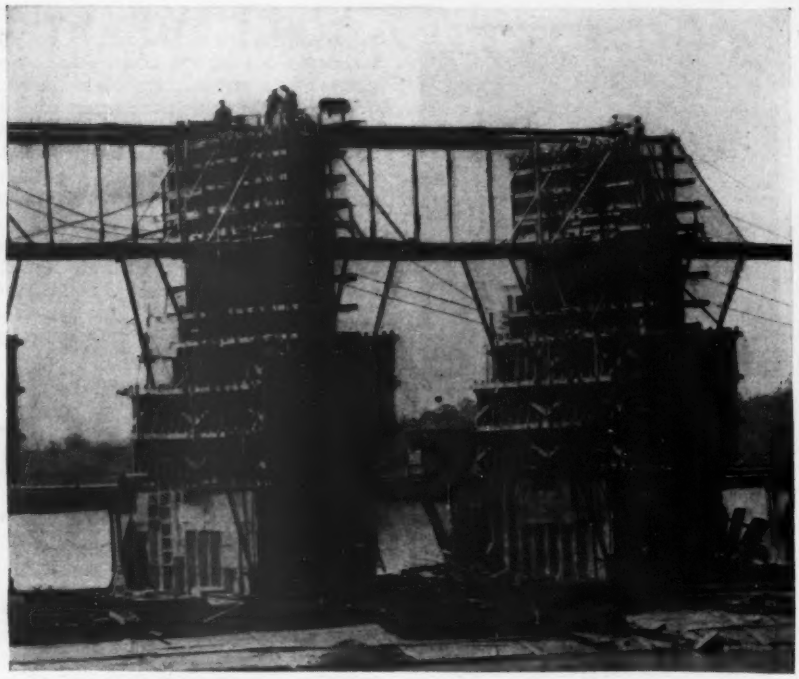
For the entire length of the structure beyond the deep powerhouse excavation, which went into very uniform rock, thorough grouting is undertaken to insure an entirely tight foundation. Two lines of 2½-in. holes spaced 20 ft. between rows and staggered 20 ft. in the rows are put down to a depth of 20 ft. with the wagon drills. One line is 1 ft. upstream and the other 19 ft. downstream from the axis of the dam.

These holes first are tested hydrostatically at 38-lb. pressure. Practically no mud seams have been found, so that no washing out has been necessary. With few exceptions, the holes also show little or no loss of pressure when tested.

Neat cement grout is forced into the holes with a portable air-operated duplex plunger pump. While a hole is being filled, caps on adjacent holes are removed, to permit flow through any seams found. Very few holes have shown any indication, however, of receiving grout from those near them.

Beginning with 20 lb., the pressure was gradually stepped up to 50 lb. without any measurable movement of the rock. This pressure is now maintained on all holes for 10 min. In practically all cases the holes take only enough grout to fill them.

High-pressure grouting is done after



FORMWORK FOR SECTIONS OF DAM that are built to full height to carry the construction bridge are kept in proper alignment by two lines of timber struts.

a minimum of 10 ft. of concrete has been placed on the foundation. To facilitate this second sealing of the foundation, grout holes are drilled before the concrete is placed. Pipes in these holes are extended to above the desired level. At the proper time the grout pump fills these holes under 100 lb. pressure. In none of these latter holes has there been noticeable loss of grout.

All questionable joints or fissures in the rock foundation have been explored with 36-in. core-drill holes. With holes of this size it has been possible to lower an engineer on a boatswain's chair so he might study the exposed face of the rock. In no cases have uncertain conditions been found. These inspections also have disclosed excellent grouting effects.

Considering the character of the rock surface and the weathered top strata of the riverbed, comparatively little difficulty has been experienced in unwatering the cofferdams or in keeping them dry enough to avoid interference with operations. The first cofferdam was built of the Ohio River type of timber walls with earth filling. The second cofferdam was built of fills of rock spoil from the excavation in the first cofferdam, with a clay blanket on the water side to obtain tightness. As a result of experience with the two types, the decision was made to build the Ohio River type for the third, fourth and fifth cofferdams. The volume of inflow in no case has been excessive, but the timber cribs have proved more satisfactory.

Rock excavation in the cofferdams is handled in 10-yd. dump-body motor trucks loaded by electric shovels. These trucks operate up grades as steep as 10 per cent. They deliver either to the rock-fill cofferdam or to spoilbanks upstream and downstream.

Dredging concrete materials

Sand and gravel for the concrete are produced and delivered under contract by the Cumberland River Sand Co., of Nashville, Tenn. Operations were started in the river at a point 35 miles below the project. When the supply at that point was exhausted, the dredge was moved about 15 to 25 miles downstream, where most of the material is now being obtained.

The material contractor operates one of the largest and most modern dredges of the type used in this country, with an average capacity of 200 tons per hour, maximum 270 tons per hour, under the local conditions. This dredge is equipped to produce simultaneously four sizes of material, all thoroughly washed and accurately sized. Sand specifications include all that passes a 4-mesh screen. Gravel is divided into three sizes: 4-mesh to ¾-in.; ¾- to 1½-in.; and 1½- to 3-in. A crusher on the dredge for reducing oversize is rarely used. Because of an overabundance of pea gravel in the river deposits, excess yardage must be handled to obtain the required amount of sand.

One of the main problems of the project is to maintain a flow of materials from the dredge to the mixing plants so that the latter will always be amply supplied. This has been done, in spite of the unavoidably wide variations in demand from time to time. Dredging and transportation plant operations also have been conducted in such manner that not more than 10 per cent of the total quantities have had to be stored enroute as a reserve against emergencies. In other words, the materials have gone from the dredge directly to the mixing plants on the job.

With a fleet of over 60 steel barges and two towboats the contractor is confronted by some of the worst navigation conditions on the lower river. It has been necessary to operate through three locks, one of which is an antiquated lock that will pass only two barges at a time. One stretch of the river channel also is so narrow that swift current requires each barge to be pulled for a distance of about half a mile with a tow line anchored on shore. At flush stages of the river swift currents also occur at various other points in the distance to be towed. In spite of these conditions, the material contractor has caused no delays to the work on the dam.

Mixing and placing concrete

Lake Wilson offers a navigable depth to all parts of the Wheeler Dam construction operations. General conditions surrounding the operation of the four floating mixing plants used in building the dam were discussed, and the details of the design of these plants were summarized in a previous article (*ENR*, Oct. 4, 1934). In general, these plants have been operated as was contemplated at that time. Each plant is moored with the mixer end of the barge against the cofferdam. Two material barges are placed on each side, and a cement barge is in the rear. Schedules are worked out in advance so that reserve supplies of materials are available on barges moored in the vicinity.

Concrete is delivered from the mixer to place in the forms in 2-yd. buckets handled by a gantry crane inside the cofferdam. Experience in operation of the gantries has demonstrated the desirability of equipping the latter with traveling mechanisms. As first installed, these units were without the latter and were shifted by hauling themselves ahead with a line on a drum on the hoist. Due to need for more frequent shifting than was expected, the addition of traveling mechanisms proved desirable.

Another major problem of the project is the construction, erection and shifting of forms. As indicated by the accompanying photograph, a vast amount of forming is required, between 10 to 12 million feet of lumber being estimated. For the powerhouse structure and superstructure very little re-use of forms was practicable. On the rest of the job sectionalized forms have been developed, which permit re-use numerous times; but since lumber is comparatively cheap in the vicinity of the job, it is more economical to replace damaged forms than to repair them.

Between the powerhouse and the lock the unusually long spillway and non-overflow sections of the dam make a

stepped scheme of construction operations desirable. That is, work tapers up from excavation at the outer end of operations through the base of the dam section, the apron and the pier sections so that a maximum of men and plant may be employed simultaneously. This program also permits standard forms to be used repeatedly for the same purpose.

Concrete is poured in 5-ft. lifts on all of the dam sections except in thin piers. Forms are accordingly made of that height. As the construction pier sections are uniform for similar locations, standardized lengths of forms are possible. Where the slope comes on the spillway sections, the full-length side-form sections are merely extended beyond the finished line of the concrete.

The usual methods of anchoring form sections for each lift by means of sleeve rods embedded in the concrete are used. Satisfactory bracing of the forms for the relatively high piers carrying the roadway which surmounts the dam has been worked out. Two sets of horizontal timber struts, one midway of the height and one at the top, span the 40-ft. opening between each two piers. These hold the forms for the latter against pushing out; steel anchor rods, with turnbuckles for proper tension, are trussed across between the two sets of timber struts to keep the forms from moving inward. With this set-up, form alignment for the piers has been easily maintained. Erection and dismantling procedure with the aid of one of the gantries also is rapid and simple.

Four six-hour shifts are employed six days a week on most of the project, a system of lighting has been developed so that the efficiency of the night shifts is surprisingly close to that of the men who work in daylight. In fact, during the hottest part of the summer there is little difference between the man-hour output for the different shifts. Intricate formwork and similar close operations are conducted largely in the daylight.

A. E. Morgan is chairman and chief engineer of the Tennessee Valley Authority. C. A. Bock, assistant chief engineer, has direct charge of all TVA engineering and construction. C. H. Locher is construction consultant, and A. J. Ackerman, construction plant engineer. Wilfred M. Hall is construction engineer, and George P. Jesup, construction superintendent on Wheeler Dam.

Unique Floor Plan Used in Low-Cost Brick House

AN INTERESTING ATTEMPT to secure maximum economy of space and low cost in a small residence is embodied in a four-room dwelling recently opened in Canton, Ohio. Sponsored and financed by the Metropolitan Paving Brick Co., the house, it is reported, can be sold for $1,725, including a 3 per cent state sales tax. The architect is Max A. Montgomery, of Hudson, Ohio.

Arranged in the form of a square, the house is oriented diagonally on the site, to give it an appearance of greater size. Its unique floor plan will be noted from the accompanying sketch, which shows how the bathroom is placed in the middle for greatest accessibility, the monitor roof directly over the bathroom provides sunlight all day long as well as affording ventilation. A wedge-shaped room is placed in each corner of the square. Windows are located in the corners of the rooms, to assure cross-light, avoid shadows, provide ventilation without draft and increase wall space. Exterior doors are placed at each of the four corners. Rooms are made the same size in order to standardize construction.

An interesting detail is the indenting of the walls, to relieve the monotony of the square and to add stability for a light-weight wall. The architect states that the esthetic and practical reason for the wedge-shaped rooms is to give an appearance of size and defeat the laws of perspective. The house is built on the ground.

Heat originating in a heater in the bathroom travels through an overhead duct system with inlets in the ceilings of the rooms and outlet grills at all windows and doors. Heat travels back under the floor to the under side of the heat compartment, where an ordinary house fan is located. The house may be cooled in summer by installing a cooling unit in the heating compartment and reversing the fan and the flow of air. Sides, roof and floor are insulated with rock wool.

FIG. 1—NOVEL BRICK RESIDENCE built in Canton, Ohio, to sell for less than $2,000, exclusive of land.

FIG. 2—UNIQUE FLOOR PLAN in which wedge-shaped rooms in the four corners of a square layout surround a central bath and heating compartment.

Artesian Waterbed Revealed in North Dakota

A survey of the Minot area, comprising about 2,800 square miles in the north central portion of North Dakota, conducted by the U. S. Geological Survey as a public-works project in 1934, revealed a rather extensive artesian waterbed. Throughout the Minot area, water is so generally found in coal beds that wells are drilled to the coal in order to obtain water. The Des Lacs artesian area extends, in a narrow belt from 1 to 3 miles wide, north of Berthold southeast through Lonetree and Des Lacs to a point a few miles south of Minot. In this area water under considerable pressure can usually be found within about 300 ft. of the surface. Many of the wells overflow at the surface and yield enough water to meet domestic needs, while the others that do not overflow have water standing only a few feet below the surface. In three small areas lying to the south of the Des Lacs artesian area, drilled wells that have encountered flowing water at depths of less than 150 ft. indicate that the areas are underlain by water under considerable pressure.

The Behavior History of The "Big Muddy"

The works of civilization have brought a new Missouri River far different in its behavior from the erratic stream of a hundred years ago

By Roy N. Towl
Mayor, Omaha, Neb.

THE LENGTH of the Missouri River from Sioux City to Portsmouth, or from the mouth of the Big Sioux River to the mouth of the Platte River, in 1804 at the time of the Lewis and Clark exploration was about 250 miles (Fig. 2). Today it is about 150 miles, indicating a shortening of 40 per cent. Naturally two questions are raised. What caused the shortening of the river channel 100 miles? And will it come back?

My conclusions are: civilization (with removal of heavy timber) is responsible for the shortening, and the results are permanent.

The old river and its valley were made by the processes of erosion and sedimentation. The natural streamflow of the river and its tributaries from the entire drainage area furnished the energy for all the work performed by the river system. The resistance encountered by the stream consisted principally of a heavy growth of timber in the valley, with other vegetation and certain soil formations, including extensive beds of clay.

The behavior of all rivers is governed by a law which prescribes their length. The necessary amount of meandering or departure from direct courses depends upon the energy of the stream, modified by all resistances of every kind and character. Energy is measured by volume, width, depth and slope of water.

The slope of an alluvial valley or flood plain depends upon the energy of the stream and the extent and character of the resistances. If the energy is dissipated, weakened or reduced and the resistances become greater relatively, then the necessary slope of the valley is increased. However, if later on these resistances are reduced or cleared away and the energy is no longer dissipated but is regulated and confined, the result will be reflected in a change such as was observed in the case of the Missouri River herewith presented.

The older river

Just 100 years ago on the exploration of Maximilian, his steamer "Yellowstone" had extreme difficulty in making the upstream voyage through a channel almost entirely filled with snags (Fig. 1). At about the same time Timothy Flint, a Presbyterian missionary on the lower Missouri River, observed "The river had the appearance of a field of dead trees." This natural condition offered a very heavy resistance to the direct flow of the river and was one of the causes for making so many bends in its course. Those snags came from a number of varieties of heavy timber growing along the banks of the river, including elm, walnut, oak, sycamore, cottonwood and willow. Everywhere the shifting banks of the river resulted in the formation of new bends, rapidly cutting off old bends and causing a shifting unstable course. When a bend was cut off, it was slowly filled with fine-grained clay deposits, while the coarser sediments were heavily deposited along the banks of the live stream, thus leaving the cutoffs away from the stream in the form of partly filled lakes and ponds. When these clay deposits in the cutoff lakes were encountered by the meandering river, an added resistance in the form of "gumbo points" was encountered, which contributed to the crooked meandering course of the river by inducing cross-currents (Fig. 3) and turbulent flow, with suction and pressure eddies thrown against the outer banks with destructive force, and eventually forming new bends and making new cutoffs. This terrific erosion of bank lines has been observed in a number of places to reach a rate of 900 ft. in 90 days.

Getting back to the heavy timber again, the Indians could not and would not cut or use trees 3 or 4 ft. in diameter. However, civilization, with its sawmills, steamboats and farming opera-

FIG. 1—MISSOURI RIVER SCENE just a century ago as painted by Charles (or Karl) Bodmer who accompanied Maximilian, Prince von Neuwied, in an expedition into the interior of North America traveling up the Missouri River in the steamboat "Yellowstone."

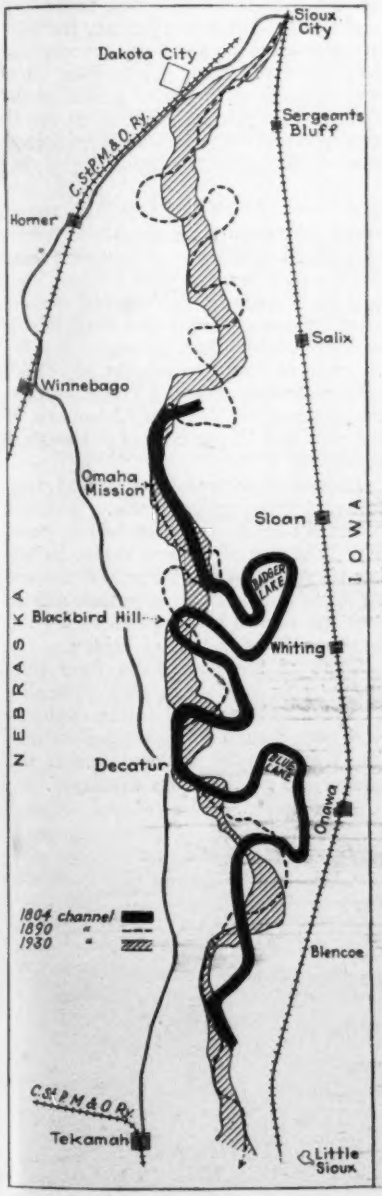
Nebraska State Historical Society Photo

tions, cleared practically all of this heavy timber, and consequently the snags disappeared from the river.

Shortening begun

With this lessened resistance, the more energetic river responded by shortening its course. Then in the year 1881 there occurred a great flood. At that time the tonnage record of navigation was near the peak, before its fatal elimination contest in competition with the new railroad system. Significantly, the river changed its behavior in a very marked degree. Since then, there have been no cutoffs from Sioux City to Plattsmouth, and the meandering and misbehavior so notorious in reputation gave way to a new record and a new deal for the river from Sioux City to Plattsmouth, as well as in many other places.

FIG. 2—CHANGING CHANNEL of section of the Missouri River as recorded in 1804, 1890 and 1930, as compiled by the author.



The proposed Lewis and Clark National Park extending from Sioux City, Ia., to Decatur, Neb., comprising land in both states, will embrace the abandoned bends of the river back to 1804, which territory now has a nearly straight river, as shown by the accompanying map (Fig. 2). One great loop measured more than 18 miles, and 40 miles of the meandering river measured 10 miles by airline distance. This map compares the old and new courses. The direct course of 1930 from Sioux City to River Sioux is 50 miles by railroad, 55 miles by river, and probably more than 100 miles in 1804.

Speaking of energy, one will observe four points of concentration where the river is now confined to a width of $\frac{1}{4}$ or $\frac{1}{3}$ mile. Going downstream from each of these places and leaving the narrow concentrated locations, the river expands gradually to abnormal widths of nearly 2 miles, where formerly the approximate width would be $\frac{1}{3}$ to $\frac{1}{2}$ mile. This new river condition, with its inefficient width, readily causes ice gorges, as in the Platte River, which is the largest tributary of the Missouri. For illustration, in 1923 an ice gorge below Dakota City, where the river is $1\frac{3}{4}$ miles wide, backed water into the Exchange Building at the stockyards in Sioux City; and incidentally there was no running ice in the river at the time, but the slush ice formed by the blizzard was sufficient to block all of the channels of the river and caused an ice gorge that could not be dislodged by bombing or any other method. The gorge held until a high stage of water carried it out.

Apparently the soil structure of the valley will not withstand increased velocities caused by shortening of the river. The new type of river under present conditions requires increased width and decreased depth, shown by the illustration.

Before leaving this subject, I want to add one more observation at Blencoe Bend several miles above River Sioux, where the channel is $\frac{1}{4}$ mile in width at the head of Little Sioux Reach. It expands gradually along a straight course occupied continually since 1881 and reaching a width of about 1 mile. All of the "gumbo points" along this course and practically all of the heavy timber have been removed. The banks are of sand, the bed is of sand, the bars are of sand and support only a small growth of willows. The run of ice has retarded or prevented larger growth on these bars.

Future probabilities

The old crooked river was subject to frequent and destructive floods. The new straight river has reduced flood levels as much as 8 or 9 ft.

The approved government river-channel contraction projects will add energy and depth to the river. This should result in lowering the bed and the normal water level of the river to some extent

FIG. 3—CROSS-CURRENTS moving a bend downstream by eroding convex bank; this bend has moved downstream 1½ miles in about 30 years.

and eventually reach down to a harder bed formation.

Looking forward, the beneficial uses of water will reduce the flood volumes and the destructive energy heretofore observed. Increased low-water flow will be derived from the Fort Peck Reservoir and will add to the energy that is necessary at low water to keep and maintain a clear channel for navigation.

Straightening of the river and the new conditions present many factors favorable to permanent stabilized conditions in this valley. Perhaps this is the world's record. The natural straightening of the Missouri River by shortening its course 40 per cent has destroyed thousands of acres of fine farmland. It has left a new type of wide shallow sand beds to replace the old crooked course.

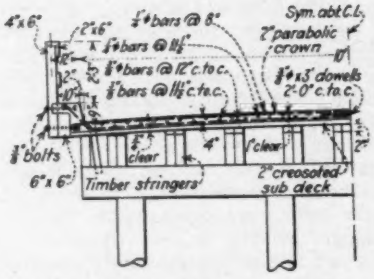
So we are glad to welcome the new straightened and regulated river. The proposed Lewis and Clark National Park, which embraces all of the abandoned river channels in the valley as well as the beautiful hills along the eastern side of the Indian reservation in Nebraska, will be a fine memorial with inspirational, educational and recreational advantages sufficient to qualify under the National Park requirements.

Concrete Decks Extend Life of Old Timber Trestles

By L. C. Winterton
Engineer for Jackson County, Miss.

IN ORDER to reduce maintenance costs and provide a safer, smoother roadway, Jackson County, Miss., has placed a 4-in. reinforced-concrete deck slab and safety curbs on six existing creosoted timber bridges with a total length of 2,890 ft. across the tidal marsh between the east and west forks of the Pascagoula River. Located on a section of the "Old Spanish Trail" (U. S. Route 90), which was constructed by the county in 1916 and is still maintained by the county without state or federal aid, the bridges form a link in one of the principal transcontinental highways and, being on the only direct route between Mobile and New Orleans, carry heavy seasonal and holiday traffic. Year-around traffic records show an average of more than 600 vehicles daily.

The bridges, constructed in 1916, were originally decked with 3 x 6-in. creosoted lumber. In 1923-24 adjacent sections of the highway were paved. Increased traffic accelerated deck wear, and soon maintenance costs were prohibitive. By 1929 it was necessary to replace the decks completely, and it was decided to cover them with an asphaltic wearing surface, to protect them from vibration and abrasion. Unfortunately, however, it was also decided to dip the new decking in coal tar on the job, thereby effecting a saving in cost as compared with having it creosoted by the usual method. The decking was dipped green, and the coal-tar coating, by sealing in the sap, hastened its decay rather than retarded it. By the latter part of 1933, damage from decay and from termite infestation had become so widespread that renewal of the decks was again necessary.



CONCRETE DECK 4 in. thick, placed on a subfloor of 2-in. creosoted lumber in timber-trestle repair job.

Providing employment for local labor was a major consideration, and the new work was performed by force account. It was desired to construct as permanent a deck as consistent with the probable life of the substructure, but the bearing value of the existing pile bents precluded the use of concrete decks of conventional design, because of excessive dead weight. Also, the factor of cost had to be taken into account. A 4-in. reinforced-concrete deck slab, with 9-in. curbs and heart-cypress hand-rail, placed over a 2-in. creosoted lumber subfloor was decided upon. The subfloor was placed diagonally, to serve as a permanent stiffener as well as for the bottom form for the concrete. Expansion joints ½ in. thick were placed over each support. Also, to avoid cracking of the slabs from deflection under load and to obtain greater efficiency from the stringers by eliminating concentrated loads at their center points, ¼-in. joints were placed at the third points of the spans. Concrete of 3,500 lb. per sq.in. compressive strength was placed from a mixer floated on a barge alongside the bridges.

As was expected, the replacement of some substructure members was necessary. Practically all replacements were necessitated because deep cuts or daps had been made in the original timbers after treatment, or by the development of shakes, which had permitted termites to enter or water to remain in contact with untreated wood. These replacements amounted to about 12 per cent of the caps and 15 per cent of the original stringers.

Half-at-a-time construction was used, to avoid interrupting traffic. The last of the six bridges was finished in January. The cost of the new decks, including all replacements, three new lines of stringers and a 20 ft. approach slab at each end of each bridge has been slightly less than $15 per foot of bridge.

Some of the new decks have been under traffic over six months. The surface obtained has good riding qualities. And, even though a 35-ton crawler dragline was recently dragged across the bridges, no cracking has developed.

CONSTRUCTION and completed views of concrete deck placed on old timber trestles in Jackson County, Miss.

Concrete Trestle-Type Quay at English Marine Terminal

Additional accommodation for foreign passenger and freight business, as well as car-ferry service, provided at rail-and-water terminal by London & Northeastern Railway—All poured concrete, except precast piles—Freight-handling equipment

By E. E. R. Tratman
Wheaton, Ill.

CONCRETE QUAY construction of the open-frame or trestle type, as distinct from the older type of heavy masonry retaining wall with solid backfilling, is being increasingly favored for harbor works in Europe. Some of the new quays at the port of Havre (France) are of this open-frame type (*ENR*, June 14, 1934, p. 768), and a still more recent example is an extension of the Parkeston quay of the London & Northeastern Railway (England). With this new extension of 1,120 ft., which was put in service in October, 1934, the quay has a total length of nearly 4,000 ft.

At Parkeston, on the east coast and 70 miles from London, the railway has an important marine or rail-and-water terminal for passenger and freight business. It serves a number of steamer lines across the North Sea to various ports on the continent, as well as the railway's car-ferry services in connection with continental railways. The quay extends along the side of the River Stour, about three miles above its mouth, and in the rear are the railway's main line, freight yards and other terminal facilities. The shore is flat and swampy, so that the yards and all other works are on filled land. There is a tidal range of about 12 ft., with a maximum of 15 ft. Hydraulic dredges have deepened the river to permit vessels of 20-ft. draft to come alongside the quay at any stage of the tide. The dredged material was pumped ashore to fill low ground.

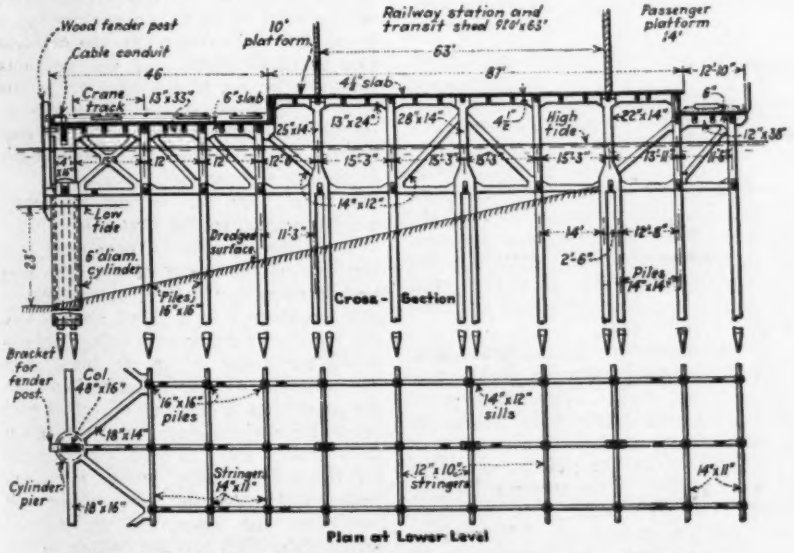


FIG. 1—NEW QUAY at Parkeston, England, is of precast concrete pile and concrete frame trestle, concreted in place.

Design of quay

This 1,120-ft. quay extension is of the general design shown in Fig. 1. For 920 ft. of its length it has a part of the deck raised, as shown, to form the first floor of the two-story transit shed and railway station, 920x63 ft. Beyond this, for 200 ft. to the connection with the older part of the quay, the deck is flat for its entire width. Brick walls fill the spaces between the columns along the edges of the raised section of the deck. The structure is designed for a live load of 1,000 lb. per sq.ft.

Along the river side of the quay are three stub tracks, with cross-over connections and a double-track approach. Two of these tracks are in front of the transit shed, and the other is near the water edge of the quay. This third track is between the rails of a track of 15-ft. gage for the traveling portal cranes, which thus straddle the cars and can handle freight directly between ships and cars. At the rear or land side of the quay is a single track for the use of passenger trains run in connection with the steamer services. The 63-ft. width of building on the raised deck leaves a 10-ft. platform on the freight or river side and a 14-ft. passenger platform on the opposite side. This latter platform is covered by a glass canopy roof carried by cantilever trusses.

Pile and frame construction

Concrete piles, generally 40 ft. long, are driven in bents spaced 12½ ft. c. to c. In the bents the spacing of the piles varies from 11½ ft. to 15¼ ft., to suit the column spacing in the superstructure. Under the transit shed there are three sets of twin piles, 30 in. c. to c., capped to support the columns. Where a part of the quay is on a curve of 1,325-ft. radius, the bents are arranged radially, with the 12½-ft. spacing in the front row. Piles in the first four rows from the face are 16 in. square; all the others are 14-in. square.

To afford ample lateral resistance to shocks from vessels coming alongside, the face of the quay is carried on pairs of the 16-in. piles at intervals of 25 ft., and each pair of piles is surrounded by a precast concrete caisson or shell 6 ft. in diameter. The caisson, which has a steel cutting edge, is lowered into place over the piles and then filled with concrete to form a solid pier. In this respect the construction is somewhat similar to one of the Havre quays, mentioned above, but in the latter the caissons were 14 ft. square and enclosed a group of nine 20-in. concrete piles.

On the face of each of the Parkeston caissons is a bracket to form a seat for a vertical post of the timber fender. No allowance is made for the load-bearing capacity of the caissons, only the piles being relied upon for support. Upon all the piles, and bonded to them, are columns of rectangular section capped by transverse girders and connected by sills at low-tide level. Stringers framed between the girders at panel points carry a deck of the slab and beam type. This slab is 6 in. thick, increased to 10½ in. for a width of 4 ft. under the outer crane rail, near the water edge of the quay. But where the slab forms the first floor of the transit shed, its thickness is reduced to 4½ in. The horizontal and vertical diagonal bracing in each 275-ft. bay between expansion joints is shown in Fig. 2.

With the face of the quay supported by the concrete piers at alternate bents, horizontal diagonal braces in the outer panels transmit shocks to the adjacent bents. Vertical diagonal bracing is introduced in the panels of the alternate bents at these piers, to afford additional

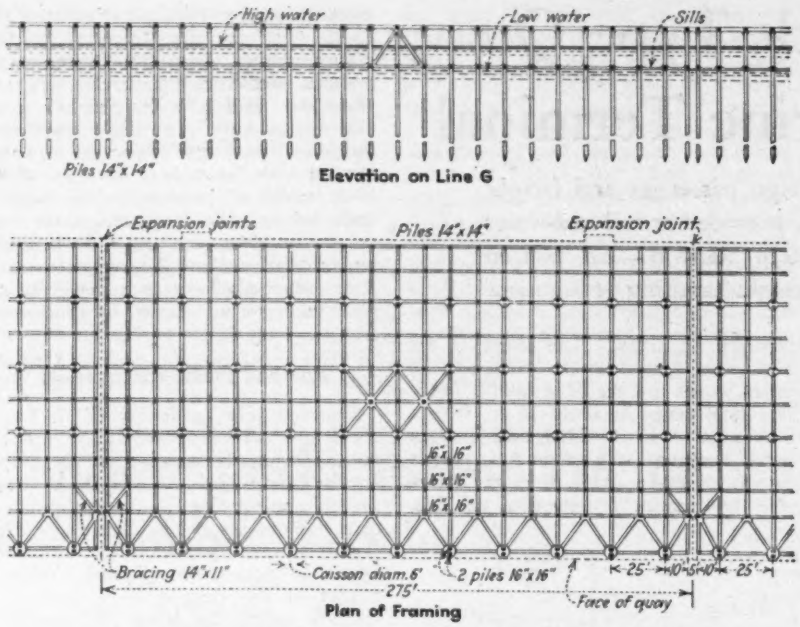


FIG. 2—FRAMING of typical panel of quay includes horizontal diagonal bracing and vertical bracing between bents. The elevation shown at the top is of the line at the rear of the horizontal cross-bracing at the panel center.

lateral stability. The facia girders of 25-ft. span between the columns on the piers are 14x36 in. in section.

The columns under the face of the quay, built upon the piers, are 48x16 in.; intermediate columns built on the piles are from 14 in. square to 14x28 in. The caps or transverse girders of the bents are 13x33 in. in the front panel and then 13x24 in. At the face of the quay they are cantilevered 3 ft. beyond the columns to form brackets against which the fender posts are secured. At the rear of the quay these girders are also cantilevered 3 ft. beyond the columns. The deck beams or joists are mainly 9x13 in., spaced 46 in. c. to c. In the lower stage of the bracing, the transverse sills are 14x12 in., and the longitudinal stringers 14x11 and 12x10 in., except that those of 25-ft. span between the cylinder piers are 18x16 in. Kneebraces or haunches are arranged at connections of all horizontal members to the verticals.

Along the face of the deck slab is a 9-in. curb 18 in. high, which, with a 9-in. brick wall on the deck, forms a cable conduit, covered with precast concrete slabs. Upon the concrete deck is a 14-in. bed of sand and a 4-in. tarmacadam paving, the finished surface being flush with the curb and conduit. Drip pipes in 2-in. holes near the front of the quay, with funnel-shapped tops covered with gratings, provide drainage for the deck and filling. A protective fender consists of timber posts 16x16 in. seated on brackets on the cylinder piers and bolted against the ends of the cap girders of the bents. Between the posts is a line of horizontal creosoted timbers 12x12 in., bolted against the face of the curb wall along the face of the quay. Alternate posts extend 3 ft. above the surface of the quay, as a precaution against the case of exceptionally high tides. On the faces of the posts are bolted ½-in. steel chafing plates, and their tops are covered with zinc caps.

Three expansion joints with 2-in. openings extend across the entire width of the deck. They are covered with 7-in. steel plates ½ in. thick, set in recesses in the top of the concrete and anchored to the slab on one side of the opening. The recesses have a bituminous mastic filler. At these joints the two adjacent bents are 5 ft. c. to c., with the next bents 10 ft. from them, so as to maintain the normal spacing of 12½ ft.

For the freight tracks along the front of the quay, ties are laid on ballast filling, with guard-rails to form the flangeways in the paved surface. For the crane tracks, however, 100-lb. T-rails are bolted to concrete longitudinals on the deck and have steel guard angles 3x6 in. to form the flangeways. For the single track along the rear of the quay, the ordinary ballasted track is laid on the slab. A pipe handrailing on concrete posts bolted against a curb, which retains the ballast, extends along the outside of this track.

Construction methods

With the exception of the precast piles, practically all the concrete of the Parkeston quay was poured in place. In this respect, the work differs essentially from the Havre quays already mentioned, where the framing consisted of precast members. The work of placing forms and pouring concrete in the lower part of the structure was attended with some difficulty, because of being below high-tide level. The sills of the bottom set of bracing are only about a foot above normal low tide.

Concrete piles 40 ft. long were driven to a penetration of about 16 ft., the last 7 ft. being in a gravel formation underlying the soft river mud and silt. The piles were handled by a 5-ton locomotive crane. Piledrivers with 3-ton steam hammers worked on the deck of a temporary timber-pile trestle extending the full width of the work. Part of the deck and framing was taken up and shifted forward as the piledriving progressed. At one place an old masonry retaining wall was encountered, through which holes for the piles were punched by means of a timber pile shod with a heavy iron point. The specifications required that penetration under the hammer should not exceed 1 in. for the last fifteen blows with a drop of 2½ ft. In practice, after being driven to resistance, the penetration averaged about ¼ in. per blow and finally ¾ in. on fifteen blows. A few piles went below grade before the required limit of penetration was reached, but the resistance became much greater if driving was stopped for a while. At the twin piles the second frequently went deeper than the first pile.

With the piledriving completed, the concrete of the heads of the piles was broken away to the level of the bottom sills, or about a foot above normal low tide, the reinforcing bars being left exposed for about 30 in. to bond with the concrete of the columns built on the piles. As a few piles were driven below the desired elevation, their heads were broken away to give sufficient lap for the column bars, which were extended downward for the purpose and bent into the kneebrace connections between the piles and the bottom of the sills.

Most of the precast cylinders were in single lengths of 24 ft., but for convenience in handling with the lighter cranes on part of the work, some of the cylinders were made up of two lengths of 15 and 9 ft., with annular tongue-and-groove joints. When two piles for the pier were driven, the mud was dredged away to give a clean bottom, and three timber guide-piles were driven on a circle of 6-ft. diameter, within which the caisson was lowered by a crane. Penetration of the cutting edge was effected by striking the caisson with a long timber or by raising and dropping the caisson a few feet at a time.

A diver leveled the surface in advance and afterwards inspected the sealing of the caisson; with the two section caissons he also inspected the joints. Small sacks of concrete were dropped into the caisson to seal the bottom, after which the vertical reinforcing bars were set in position and concrete filling was placed under water

by means of a tremie. Forms were used for the top of the pier, above the caisson.

Marine concreting

For the construction of the concrete superstructure of the quay, a part of the temporary trestle for the pile-driving had been left in place, and from this the forms for the lower section of the work were suspended by cables. The trestle thus carried the weight of the poured concrete. Wood forms were used throughout, except the steel forms for the precast caissons. Since concreting of this lower section was limited to periods of about four hours at low tides, this work was done by day and night, according to tide conditions. But a good part of this working time was occupied in clearing the forms and reinforcement from silt deposited during high tide. Occasionally, the water did not recede to its normal low-tide level, so that work had to be postponed.

For this part of the work the mixing plant was mounted on a barge, and the concrete was placed by wheelbarrows on plank runways. The lower parts of the columns and the inclined braces were poured at the same time as the horizontal beams or sills. After the concrete in this part of the structure had set, the forms for the upper part were placed and the concrete, up to the level of the haunches of the girders and stringers, was poured from the deck of the temporary trestle. After the girders and stringers had been poured, the deck beams were concreted in forms supported on the finished work below. The pouring of the deck slab completed the structural work.

Gravel concrete of 1 : 2 : 2¾ mix was used, made in ½-yd. mixers and distributed mainly in wheelbarrows on plank runways. Compressive tests are reported as showing strength of 5,900 and 7,900 lb. in fourteen days and twelve months, respectively. All steel reinforcement has a minimum cover of 1½ in., but all concrete below the deck (including the bottom of the deck slab) was given two coats of tar paint. This is mainly as protection for the reinforcement, but it also prevents the accumulation of marine growths on the concrete parts.

Transit shed and quay equipment

Passenger facilities and freight storage are provided in the transit shed, a two-story structure, 920x63 ft., of steel-frame construction, with concrete floors. In the first story the headroom is 15 ft., and in the second story it is 12½ ft. clear under the triangular roof trusses. Two continuous skylights on each slope of the roof give good daylight for this upper story. Its floor has concrete platforms cantilevered outside large doorways on the water side, so that the cranes on the quay can handle freight directly between ships and the upper floor of the shed. There are also six electric freight elevators.

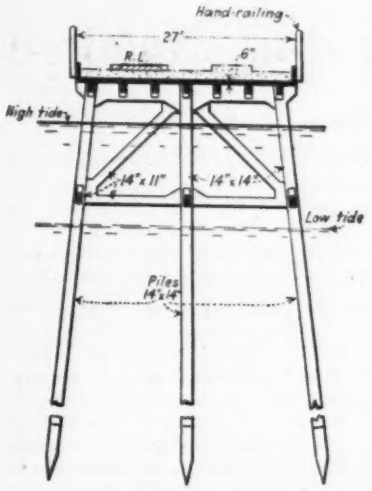


FIG. 3—CONCRETE VIADUCTS form approach to new quay at new marine terminal at Parkeston, England, for the London and Northeastern Railway.

On the water side of the building a 10-ft. freight platform extends beside one of the freight tracks. On the opposite side is a 14-ft. platform along the passenger track. Ramps with a slope of 1 in 7½ connect the deck of the quay with the raised floor of the shed. Adjacent to the building, a covered track and platform are provided for the customs examination of the sealed freight cars of foreign railways, which are moved here from the car-ferry steamers.

At the middle of the first floor are the passenger accommodations and railway station, including waiting rooms, baggage rooms, ticket office, restaurant, telegraph and telephone offices, and an office for exchange of foreign moneys. There are also the baggage-inspection rooms and customs and passport offices. These quarters are adjacent to the passenger platform.

On the quay are nine electric portal traveling cranes of 5- and 1½-ton capacity, having luffing booms that can be lowered to the horizontal position. These cranes travel on a track of 15-ft. gage and straddle one of the railway tracks, as already noted. Electric capstans mounted in covered pits in the deck enable cars to be shifted by means of ropes. There are seven of these capstans on the main part of the quay, and four serve the passenger track and its connections. Mooring posts are installed about 100 ft. apart along the front of the quay.

Approach viaducts

As the quay extension was built a little distance out from the shore line, its railway approaches at the end are built on two curved concrete viaducts or trestles extending across a small bay that may be filled later for a widening of the freight yards. The double-track viaduct (Fig. 3) serving the freight tracks at the front of the quay is about 550 ft. long and is composed of three-pile bents with 14-in. concrete piles, the outer piles being battered. The bents, 12½ ft. apart, have concrete caps 12x24 in., with stringers or joists 9x13 in., about 46 in. c. to c., and a 6-in. deck slab 27 ft. wide. Longitudinal and transverse sills are built just above low-tide level, with diagonal members above them, as shown.

For the single passenger track along the rear of the quay, the viaduct, about 500 ft. long, has two-pile bents of batter piles 16x16 in. The arrangement of caps, sills and deck is very much the same as in the other trestle, but the deck is 16 ft. wide and X-bracing is built between the two piles. Each viaduct has a 2-in. expansion joint at the middle and at its connection with the quay. These joints are covered in the same way as those in the deck of the quay. At the middle of each section formed by the middle expansion joint, four bays or panels have longitudinal and transverse diagonal bracing to insure stiffness of the structure.

Ballasted track construction of the standard type is laid on the viaducts. Each has a hand-railing on both sides, consisting of concrete posts bolted outside the deck curb (which retains the ballast) and carrying three lines of pipe rails. Short earth embankments connect the viaducts with the existing tracks.

Engineers and contractors

The concrete quay and viaducts were built by the Yorkshire Hennebique Contracting Co., of Leeds; the building was erected by George Longden & Son, of Sheffield. Design and construction of the entire project were done under the direction of C. J. Brown, chief engineer of the London & Northeastern Railway, at London, England.

Industrial Disease Codes To Be Formulated

Work is being begun on codes for the prevention of industrial diseases, especially those caused by the inhalation of toxic dust and fumes, according to a statement recently issued by the American Standards Association. Silicosis and related diseases are to be included. Specific projects for codes deal with rock drilling and granite cutting in addition to abrasive cleaning, spray coating and chromium plating.

The association says that a thoroughly bad situation has developed in the courts in respect to such diseases. Twelve states have extended workmen's compensation to cover industrial diseases, and as a result industries as well as insurance organizations feel that research into causes and prevention and the formulation of standards of practice for prevention are important.

Book Reviews and Notes

A Monthly Commentary on Current Additions to the Civil Engineer's Library

Strength of Materials

Reviewed by H. F. Moore
Research Professor of Engineering Materials, University of Illinois, Urbana, Ill.

ELEMENTS OF STRENGTH OF MATERIALS—By S. Timoshenko and Gleason H. MacCullough. Cloth; 6x9 in.; pp. 350. Line drawings and tables. Published by D. Van Nostrand Co., Inc., New York City. $3.25.

THE RAPID development of methods of computation of stress and strain that has taken place during the past decade or two has made the problem of selecting the subjects to be included in an elementary textbook on mechanics of materials one of no small difficulty. This book is a worthy addition to the group of such elementary texts that have appeared in recent years, and it is evident that the authors have given thought to the selection of subjects to be included, and have so arranged chapters and sections that any of the more advanced methods of stress analysis can be omitted without sacrificing continuity of treatment.

This book reflects the influence of continental European methods of presenting stress analyses, as might be expected (and welcomed) from as distinguished an apostle of those methods as Professor Timoshenko. At the same time the general arrangement and the free use of numerical examples and problems show an appreciation of the needs of American methods of teaching.

The extensive use of mathematical formulas in stress analysis tends to lead undergraduate students to pay insufficient attention to the underlying assumptions and limitations of those formulas; there is danger of "formula worship." This book, like most of the newer books on strength of materials, gives careful statements of underlying assumptions and limitations of methods when applied to actual materials. As is the case with any text, the teacher must face the problem of steering the student mind between the danger of formula worship and the danger of feeling that the formulas are not reliable because the behavior of actual materials differs widely from that of the ideal material assumed in developing the formulas for stress and strain. In any event this text will give the careful teacher excellent material for meeting the problem.

The usual methods are given for analysis of compression and tension members, of torsion-carrying members, and of flexural and shearing stresses in statically determinate beams. In connection with deflection of beams and with analysis of statically indeterminate beams, the double integration method, the moment-area method and the energy method are all discussed and are so arranged that any one of the methods can be omitted with very little interference with the presentation of the other methods. Special subjects include curved beams, eccentric loads on columns and energy of strain with application to impact stresses determination.

Throughout the book such subjects as statically indeterminate stress, stress concentration, and combined stress effects are introduced at several points; first in connection with the simpler methods of stress analysis, and later in more elaborate form. It is the reviewer's opinion that this method gives the student a clear and comparatively easy approach to these subjects.

Two features of the book caught the reviewer's attention: (1) the treatment of columns; and (2) the treatment of beams made of material which does not follow Hooke's law. Strength of columns is pictured as governed by two independent criteria—buckling and yield strength of material. This idea is extended by the concept of change of modulus of elasticity of metal stressed beyond its elastic range, and a diagram is shown representing the field covered by these two criteria, with the sharp intersection at the point where the effects of the two criteria are the same, "rounded off" by the change in modulus of elasticity. Then the various empirical column formulas in common use are shown to fit this diagram fairly well.

The stresses in a beam made up of material that does not follow Hooke's law are treated briefly for a simple case, and this treatment leads to a discussion of built-up beams of two materials and of reinforced-concrete beams.

The concluding chapter deals with the properties of various materials, and includes a brief consideration of strain hardening, residual stress, mechanical hysteresis, properties of metals at high temperatures, fatigue of metals and theories of failure of metals. The reviewer feels that in this chapter a little more attention might have been paid to the nature of the different kinds of structural damage that cause materials to fail to function properly.

Probably neither the average American engineering undergraduate nor the average instructor in mechanics would class this as an easy book. Its effective use will require a good instructor and a well-organized teaching department, but this is true for any text in strength of materials if it is at all adequate for present-day needs. This book impresses the reviewer as highly suitable for use in courses in which there are "honor sections," whose students study special subjects in strength of materials that are deemed too difficult for the average section.

Russian Construction

CONSTRUCTION OF THE PIERS OF THE SARATOV BRIDGE—By M. A. Kienia and N. N. Lichoshersti. Cloth, 6x9 in.; pp. 496. Printed in Russian and published by State Railroad Transport Publishing, Moscow, U.S.S.R.

Reviewed by Leon S. Moisseiff
Consulting Engineer, New York, N. Y.

THE REPORT on the construction of the piers of the Saratov Bridge, the subject of the following review by Leon S. Moisseiff, is a book that under other circumstances would not be subject to review in these columns. The book is not a text on bridge foundation construction; it is simply the engineers' report on work carried on under their direction, such as is submitted to the owners by engineers in this country following the completion of most large undertakings. Its significance is found in the fact that it is probably the first report of this character to come out of Soviet Russia. Thus it may be taken as the forerunner of many similar reports in which Russian engineers will add their experience to the store of knowledge that is the basis of sound engineering.—EDITOR.

THE CITY of Saratov lies on the shores of the river Volga. An important railroad line crosses the river, which is more than a mile wide. There is no bridge for the railroad to cross, and the transfer of freight was more recently effected by a car ferry. More than 40 years ago both the city and railroad began to discuss actively the building of a bridge; numerous schemes were proposed, and many reports were duly submitted. Not, however, before the industrial development of the country began to be pushed vigorously was a bridge actually authorized. In 1929, after much study of the geology and hydrology of the site and the required freight capacity, a bridge was decided upon.

The Volga is an alluvial river, and the ground at the location of the bridge is made up of layers of clay and sand of various consistencies. The superstructure of the bridge is about one mile long; it consists of seven main spans, forming three cantilevers, two of which are 635 ft. each, and nine short spans 216 ft. each.

The book under consideration is a most interesting document. It has a historical significance that is emphasized by the story of the bridge project, which is told in full. The record of the vagaries of the project and much of the argumentation reflect the spirit of a past epoch in Russian history, of its volubility and lack of decision. The reviewer himself vividly remembers

having been visited in Moscow by an engineer fathering one of the plans and having been told with prophetic fervor that to build a bridge at the selected location would bring down ruin to the structure and its sponsors. Even the selection of the type of superstructure was argued with a flavor of sentimental revolt.

The book gives a complete record of the building of the caissons, their placing and sinking, the mechanization of the work, and the amount of material and manpower consumed. The book reminds one of the famous English construction reports of about the middle of the last century. The authors, who served as chief engineer and assistant chief engineer, were in charge of organization of the work, design and construction of the caissons, their sinking and the building of the piers. They were the planners as well as the builders. They showed skill and judgment in the utilization of the available dead and live material. Some proof of this is the fact that the actual cost of the completed work was about 20 per cent less than the detailed estimate. Three-quarters of the book is taken up with the record of the work, history of the project, study of physical conditions and of superstructure, organization of the work, triangulation, types of caissons used and their construction, sinking, caisson disease and building of the concrete piers. Some 85 pages are devoted to the computation and design of concrete caissons reinforced by steel or by timber, and their sinking equipment. To this are attached documentary records and statistical information. M. A. Kienia, one of the authors, recently wrote of his successful utilization of timber as a means of reinforcing concrete caissons (*ENR*, March 21, 1935).

The usefulness of the work for the foundation engineer of U.S.S.R. is apparent. Information contained in the book furnishes a sound basis for future planning of similar work, the cost of materials and labor as well as the cost of fuel, and housing for the men employed on the work, because in this case the planning engineers are also the contractors. It is regretted that the book is not accessible to those unfamiliar with the Russian language.

Miscellaneous Notes on Booklets and Reprints

A HOUSING SURVEY of Kansas City, Mo., prepared as a part of the Missouri ERA non-manual works program in collaboration with the City Plan Commission of Kansas City, is published in a 75-page report supplemented by many charts and maps. The booklet contains data relative to some 40 facts on housing obtained from each of nearly 130,000 family units. In many respects the housing survey followed the questionnaire used in the real property inventory conducted by the Bureau of Foreign and Domestic Commerce. Available from the City Plan Commission, City Hall, Kansas City, Mo. Price not stated.

A DESCRIPTION of the Manchester, England, sewage works at Davyhulme and Withington has been prepared, following the completion in 1934 of extensive improvements to the Davyhulme works. The illustrated booklet, containing 40 pages, is available from the Rivers Department, Ship Canal House, King St., Manchester, England.

AN INVESTIGATION of bell-and-spigot joints in cast-iron water pipes with respect to pull-out strength and bell strength, and tests of the strength of a harness, for retaining a 36-in. bell and spigot joint, is published as Bulletin No. 87 of the Engineering Experiment Station, Ohio State University, Columbus, Ohio. Written by Prof. John C. Prior, the bulletin contains 57 pages and is available for 50 cents.

STREAM FLOW RECORDS—1934, has been published recently by the Pennsylvania State Department of Forests and Waters, in cooperation with the U. S. Geological Survey. In addition to flow data from 110 gaging stations in the drainage basins of the Delaware, Susquehanna, Potomac and Ohio Rivers, a summary of monthly precipitation records is included with a map of isohyetal lines of distribution.

TECHNOLOGY REPORTS of the Tohoku Imperial University, Sendai, Japan, Vol. XI, No. 4, include papers on the effect of shear stress upon the strength of a straight beam, a comparison of divergent and convergent flows of a viscous and a perfect fluid, impact torsion tests, the nitrogen case-hardening of steels, and other subjects. The reports are published in English and are available from the Tohoku Imperial University.

AMONG CURRENT INDUSTRIAL STUDIES the National Industrial Conference Board (247 Park Ave., New York. $1.00) report on the claimed shortage of skilled labor in the metal-working field takes a prominent place. It presents data of an inquiry showing that metal-working has a 1 per cent of labor shortage in the skilled grades on present production and a 7 per cent shortage on the basis of full production. The inquiry covered 287 replying employers and 115,000 workers. While the data found, especially in view of their distribution and internal characteristics, do not appear particularly serious, the analysis of causes and the discussion of possible remedies is highly instructive. Employers and labor are pictured as jointly responsible. Apprenticeship and worker-rehabilitation training are mentioned as leading possibilities. The subject in hand involves the whole trend toward machine specialization and the resulting demand for operatives rather than machinists. The report has a suggestive value reaching far beyond the metal-working field.

ANALYSIS of continuous-arch systems and a theorem of nine displacements are published in a reprint from the Memoirs of the Faculty of Engineering, Kyushu Imperial University, Fukuoka, Japan. The treatise is written by Kozaburo Mise, professor of civil engineering. Both text and charts are in English.

COMPARISON of the physical properties of mortars and concretes made with a normal portland cement and a blended cement (79 per cent portland and 21 per cent natural) is given in Bulletin No. 47 of the Engineering Experiment Station, Purdue University, Lafayette, Ind., which is a report of an investigation conducted by the station in cooperation with the Louisville Cement Co. by R. E. Mills and R. B. Crepps of the station staff. Such properties as strength, modulus of elasticity, plastic flow, fatigue, expansion and contraction, and durability, as measured by freezing and thawing, are covered. Price 50c.

MASS CONCRETE setting temperatures for three large dams under construction in Scotland as compared with laboratory determination of temperature rises of concrete samples cured adiabatically, using the same cement in the field and in the laboratory, are given in Technical Paper No. 18 of the Building Research Station, Department of Scientific and Industrial Research (Great Britain). The dams are the Laggan Dam near Port Williams, the Tongland Dam, near Kirkcudbright, and the Clatteringshaws Dam, across the Blackwater of Dee. The dams are of the gravity type except the Tongland Dam, which includes both an arch dam and a gravity section. The bulletin is available from His Majesty's Stationery Office, London; price 9d. net.

New Books and Revised Editions

[Those desiring copies of the books listed below or mentioned elsewhere in this section should order them from the publishers or from their local booksellers.]

SURVEYING—By Harry Bouchard. Fabricoid; 5x8 in.; pp. 586. Maps, diagrams, tables. Published by International Textbook Co., Scranton, Pa. $3.75.

PRECISION WORKSHOP METHODS—By H. J. Davies. Cloth; 6x9 in.; pp. 306. Diagrams. Published by Edward Arnold & Co., London; and by Longmans, Green & Co., New York, N. Y. $6.75.

THE CHEMISTRY OF CEMENT AND CONCRETE—By F. M. Lea and C. H. Desch. Cloth; 6x9 in.; pp. 429. Photographs, diagrams, tables. Published by Edward Arnold & Co., London; and Longmans, Green & Co., New York, N. Y. $9.50.

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Editorial and Publishing Offices at 330 West 42d Street, New York

August 22, 1935

Engineering on the Job

WITHIN the range of work accomplished in continuous battle with deep water, tides and storms the construction of the south pier of the Golden Gate Bridge is of unquestioned preeminence. The carefully written account that occupies the leading pages of the present issue records the history of the task and the methods by which it was at last brought to sucecss after a long series of difficulties and persevering effort by the builders. But though it sets forth the facts complete, it necessarily does so with a brevity that justifies unusually careful study if the engineer who reads it is to obtain an adequate conception of the operation. Those men who finally succeeded in completing the pier may justly take high satisfaction in their achievement; it will not soon be repeated. Yet the work has an importance as an engineering document much greater than that due to its difficulty alone, and this lies in the exceptional degree to which the actual construction shaped and determined the engineering character of the structure. It needs only a comparison of the ultimate pier, its widespread base incorporating the whole area of the ring-shaped fender, with the original plan to reveal the thoroughgoing change in design that came about in the course of the work. The pier as it stands today is, in truth, the product of the construction operations themselves. Only a remarkably close and understanding study of the conditions that arose during the work could have succeeded in developing an engineering structure satisfactory and adequate to engineer as well as constructor. Rarely, indeed is the decisive importance of field engineering brought so clearly to view as in this noteworthy piece of construction.

A Delicate Task

A DEFINITE ADVANTAGE should follow success of the movement recently initiated to organize construction equipment manufacturers and distributors into a general association. The movement indicates a breadth of realization of the unity of the industry that has not been conspicuously evident in its traditions and past practices. The advance survey undertaken by the organizing committee should show how general and clear this vision is. It can be sufficiently keen to make association a success, and by the same token it can as easily be so shortsighted as to make its failure certain. Lack of vision will be shown if organization purposes are directed patently to selfish service to the industry; an economic service to construction has to be the impelling purpose for success. With this assured in the agenda of the association and purposefully carried out in its actions, the industry will receive its rewards in business and profits with far greater certainty than by price-fixing or influence on legislative action. True federation of the heterogeneous competitive elements that make up the construction equipment industry calls for organizing wisdom of high quality and purpose. The entire range of construction has an interest in the success of the task, and the hands of those undertaking it should be upheld as they prove efficient in their work.

Essay on a Definition

RECENT DEVELOPMENTS in the field of reinforced concrete raise some doubts of the justification of the term as a descriptive name for some of the current combinations of steel and concrete. In the extensive studies of reinforced-concrete columns at Lehigh University and the University of Illinois, the unusual importance of the vertical steel as a load-carrying element was forcibly brought out, and more recently the same fact has been demonstrated in connection with reinforced brickwork. Not only does the steel carry the stress assigned to it but it assumes a great deal more in the course of a few months under load. This is only possible because it is reinforced and is given lateral support by the concrete. Conversely, the spiral steel provides a toughening and supporting bond for the concrete. If such a column, made of concrete, rods and spiral wire, may be called reinforced concrete, it may also as truly answer to the name of reinforced steel. The mutual reinforcing effect is also noted in the thin concrete shell dome and vault roofs used in Europe, in which the concrete braces and confines the steel, stiffens its assemblage and holds it in position, while the steel for its part carries most of the load and makes the concrete better able to resist shear. The question raised at the outset concerning the descriptive quality of the term *reinforced concrete*, then, is obviously pertinent. But of course it does not affect the vital fact that the combined materials are stronger than either alone.

A New Tool

FURTHER DEVELOPMENTS in geophysical methods of determining earth character at shallow depths were presented in an excellent review of progress published last week. The outstanding feature of this recent research work performed by the Bureau of Public Roads is its demonstration of the practicability of seismic methods. In the minds of many experts these have advantages for the normal foundation operation over the more familiar process of using electrical resistivity measurements. Though well established for deep geological determination in mineral surveys, the seismic method has been handicapped for general foundation and particularly for highway work by the heavy equipment commonly used in mining. The essential accomplishment of the Bureau of Public Roads experiments has been simplification of equipment to make it easily mobile and adapted to rapid work. The experiments indicate that little sacrifice of accuracy was involved in the changes of procedure, and that a new tool for the highway and foundation engineer has been advanced well on its way to general and successful use.

Line Drilling

A CONSPICUOUS ELEMENT of the construction work at Wheeler Dam is the extensive use of line-drilling in excavating for the deep foundations of the power house and for many shallower rock cuts. Outside of a few large cities where rock has to be excavated true to line to avoid injury to adjoining high buildings, line-drilling in rock is exceptional in construction operations, and on the

surface it looks to be extravagant. It is interesting, therefore, to find in the account of the Wheeler Dam work (p. 259) that the saving in concrete in the powerhouse foundations obtained by the use of this method so much more than offset the cost of the added drilling as to result in the application of the method to shallower cuts made subsequently. Initially the line-drilling was not undertaken to save concrete but to avoid disturbance of the foundation rock, a stratified limestone in almost horizontal beds. The unexpected economy that resulted cannot but raise question as to whether line-drilling or channeling might not result in like economies on other rock operations, where line-drilling heretofore would not have been considered—at El Vado Dam, for example, where, according to the account published in our issue of Aug. 15, p. 211, steel lining was substituted for concrete in the spillway channel because of abnormally high overbreak in the rock. Obviously, rock conditions there or on other projects might be such as to make the line-drilling or channeling more costly; nevertheless the Wheeler Dam results clearly indicate that these are methods to be taken into consideration.

Savings Go Back to Work

WHOEVER has glanced at current construction statistics within the past three months has had occasion to note a remarkable increase in industrial contract awards over 1934. Those who followed the figures more continuously will have noted in addition that the gain continued from month to month, and that midsummer unexpectedly brought further acceleration to the forward movement. The net fact as of today is that since the end of March there has been a vigorous new activity in industrial expansion fully doubling the 1934 rate, and that since the beginning of the year a gain of nearly 90 per cent has been registered over the corresponding period of last year.

These phenomena contrast surprisingly with the experience of the past four years. Capital is evidently going back to work in the sole field where it can find creative opportunity—in industry. The great meaning of this fact for industrial progress lies in the accumulative effects of the long stagnation. Deterioration and more particularly superannuation of plant have gone on unceasingly. At the same time market conditions have been changing materially, and the adjustment of productive plant to the country's needs is by no means the same as was found adequate in '28 and '29. Thus a vast field for improvement and readjustment has been created. Further intensifying this situation is the fact that new products and new processes have been created, partly by research and partly by commercial and technical evolution, which require new facilities for their utilization. In view of such conditions the broad opportunity for putting new industrial capital to work needs no special demonstration.

That capital is going back to work in response to these demands proves that men have continued to save regardless of the pressure of the times, and that they have regained courage and confidence to the extent of desiring to renew and increase their participation in industry's operations. That is why citizen savings are once more seeking for useful investment. At the same time, the fact that industry is resuming its normal growth shows that it recognizes the new needs arising from steady increase in the demand for its products, and also that it confidently expects this demand to increase further.

No event in current economic history could be of greater meaning as an index of accelerating recovery. The growth and renewal of industry's plant is the vitalizing element of the country's economic existence, and industrial plant investment is its pulse-beat. As saved wealth is turned into the channels of new enterprise and new productive power, it in turn calls upon the construction and equipment industries to convert it into effective working capital. It is this creative process that has too long been checked and now is once more becoming active.

Supporting evidence of the forward-looking enterprise that is now active may be found in the very different field of public improvement. The resumed PWA operations since early summer have been showing a sustained high rate of project applications that reflects recognition of the need for improving public plant and facilities parallel with the new growth of industrial plant. That municipalities are turning away increasingly from dependence on free construction by the Works Progress Administration and instead are resorting to the PWA indicates a healthy outlook on the relation between financial responsibility and sound, efficient community development.

This vigorous growth now in progress is not without its proportionate obligations. It invites new thought, new planning and new methods. The engineer and the industrial planner have work to do in meeting the demands of the new growth in adequate fashion. What construction has accomplished within the past two years, notably in the great development projects that have gone ahead with unexampled speed, economy and efficiency, is a fair model of what engineering skill may contribute also to the rebuilding of the country's industrial plant.

Headlightless Highways

SODIUM-VAPOR LAMPS have been selected for the San Francisco-Oakland Bay Bridge because they give light without glare. There is assurance that the roadway will have plenty of illumination. If so, why should headlights be used by automobiles while traversing the several miles of bridge roadway? At best, headlights are no help to the driver approaching from the opposite direction; at worst they are a grave accident hazard. They have been an annoyance and a menace so long that it would be refreshing to have several miles of well-lighted roadway where headlights are taboo. Perhaps the Bay Bridge will be followed by other good lighting installations on thickly traveled routes where headlights will be unnecessary and therefore should be forbidden.

The objection has been raised that, if automobiles were to be driven with headlights out, it would mean, for most cars, that the tail lights would be out too, and emergency stops might then introduce a new hazard. Against this objection, however, it may be said that, if highways are to be lighted and the headlight-off rule is put in force even in a few places, automobile manufacturers soon will provide a separate switch for tail lights. With present equipment headlights could be dimmed, at least, without shutting off tail lights, and even this would be a great improvement over the present intolerable headlight nuisance on crowded highways.

It is urgent that progress be made toward better control of this deterrent to night driving. The indifferent lighting that has been used on some heavily traveled routes has been ineffective in controlling it. The modern lighting art is capable of far better performance, and the Bay Bridge should be an inspiration to further progress.

CURRENT NEWS

Added Funds For Chicago Sewer Work

THE SEMI-ANNUAL report of the Sanitary District of Chicago to the U. S. Supreme Court indicates that $6,000,000 was spent during the first half of 1935. Because of the unusual heavy precipitation during the period, water diverted from Lake Michigan was slightly more than the 6,500 sec.-ft. permitted. Despite the vigilance of the engineers, heavy downpours this spring have brought several reversals of both the Chicago and Calumet rivers. By the end of 1938 the court decreed (in 1930) that the flow must be restricted to 1,500 sec.-ft.

Expenditures to date on the system of sewage disposal and treatment total $113,757,000. Estimates on work still to be done amount to $96,000,000. Work is being financed through a PWA $42,000,000 loan and grant. A request made to PWA for an increase to about $58,600,000, to permit carrying out additional contracts, has been carried out by a recent contract rearrangement which has made available to the Sanitary District an increase of $16,682,000.

Work on the project financed by the original allotment is already far advanced, and the new funds will aid in complying with the Supreme Court's decision requiring a reduction in the amount of water diverted from Lake Michigan through the Chicago River. The new sum of $16,682,000 will be used for the following additional items of construction: Upper Des Plaines intercepting sewer; additional West Side sewers; Goose Island sewers; Harrison Street sewers; Halstead Street branch sewer; additional North Side sewers; Niles pumping station, syphons and sewer; Cherry Street intercepting sewer; Calumet Sewers; South Park Avenue, Stony Island Avenue, Colfax Avenue, Calumet City intercepting sewer; Argo sewer, to Natchez Avenue; Chicago River control works; West Towns intercepting sewers; North Side treatment plant extension.

The new increase will come out of the old appropriation for public works construction and will be effected through a change in contracts covering the original loan and grant awarded to the Sanitary District in 1933. Under the original contract PWA agreed to purchase bonds of the Sanitary District to the full amount of $42,131,040, and upon completion of the work a sufficient number of the bonds to pay the grant of 30 per cent of the cost of labor and materials was to be canceled and handed back to the district. In an amendatory application submitted on June 12 of this year, and which has just recently been approved, the district requested that PWA keep all of the purchased bonds and pay the 30 per cent grant in cash, thus making available $16,682,000 for the additional proposed work.

U. S. Advised Not to Buy District Canal

The U. S. government has been advised by the army engineers not to purchase the Main Drainage Canal from the Sanitary District of Chicago. Following a Congressional request, June 15, 1934, hearings were held by Lt. Col. D. H. Connolly, District Engineer, U. S. Army, in Chicago, and report made to Lt. Col. E. L. Daley, Upper Mississippi Valley Division, St. Louis, Mo., who has announced under date of August 15 that the report is unfavorable. The principal grounds upon which the adverse conclusions are based are that title to the canal is not needed to exercise control of navigation, no additional benefits would accrue nor can the purchase be justified from the viewpoint of equity. Interested parties have the privilege of appeal to the Board of Engineers for Rivers and Harbors in Washington to which the report is next referred.

National Resources Committee To Study Water Resources

A Water Resources Committee, consisting of representatives from governmental agencies dealing with water problems in addition to other experts, has recently been completed by the National Resources Committee.

Members of the new committee are: Abel Wolman, chairman, of the American Waterworks Association and Maryland State Planning Board; Thorndike Saville, associate dean of the College of Engineering, New York University; N. C. Grover, chief hydraulic engineer, Water Resources Branch of the U. S. Geological Survey; Elwood Mead, director of the Bureau of Reclamation; Jay N. Darling, chief, Biological Survey; H. H. Bennett, chief of the Soil Conservation Service; R. E. Tarbett, sanitary engineer, Public Health Service; Maj. General E. M. Markham, chief of the Corps of Engineers; Thomas R. Tate, director of the National Power Survey, Federal Power Commission; H. H. Barrows, professor of geography, University of Chicago; Edward Hyatt, state engineer of California.

The committee will be engaged in outlining a plan for effective use of water resources and the continuance of the policy set forth in the report of the Mississippi Valley Committee and in the report of the National Resources Committee.

Three Men Injured in Moffat Tunnel Blast

An air drill operated by workmen in the Moffat tunnel pioneer bore exploded an old charge of dynamite, severely injuring three men. The men were working on the Fraser River water diversion project at West Portal, Colo., when the explosion occurred on Aug. 5. The pioneer bore of the Moffat tunnel was drilled through some ten years ago and it is believed that the unexploded charge of dynamite had been placed at that time. The work in the tunnel is being carried out as part of a project to divert water through the Moffat tunnel to the city of Denver.

Molare Dam In Italy Fails In High Flood

MOLARE DAM on the Orba River in Italy, a gravity type structure 150 ft. high used to store water for hydro-electric power development, failed on Aug. 13 during a flood that, according to unconfirmed reports, was of very unusual intensity. Waters released by the failure of the dam, added to those of the storm itself, swept down upon the town of Ovada and several smaller villages doing extensive damage and causing the loss of many lives.

The cause of failure is not known but from the press reports of the flood it appears reasonable to suppose that the dam was overtopped.

The following information concerning the dam was obtained from Robert A. Sutherland, designing engineer with Lars Jorgensen, Berkeley, Calif., who spent a year with the late Senator Luigi Luiggi when the latter was a member of the Consiglio Superiore delle Acque, the body charged with the examination of plans of dams submitted for government subsidy.

Details of Molare Dam

Molare Dam is on the Orba River in the Ligurian Appenines in the province of Alessandria. It is situated about 30 miles from Genoa, which it supplies with power, but being on the northern slopes of the Appenines, the flood waters released flow north into the Po River. The nearest town of any size is Ovada, with Alessandria about 20 miles farther downstream.

The reservoir of 14,000 acre-ft. capacity is known as Lake Ortiglieto and has a catchment area of 58 square miles. Flow records show floods in spring and autumn, with generally a very low flow in the summer time, owing to the rocky nature of the catchment, the upper portions of which, however, are timbered.

The dam is shown in plan and section in the accompanying drawing. It is of gravity type, arched in plan with a mean radius of 660 ft., and has a height above river bed of 150 ft. and a base of 125 ft. The crest of the dam proper is 465 ft. long and 20 ft. thick and carries a roadway, under which pass 12 automatic siphon spillways. These operate in sets of three at slightly different levels, so as to come into operation successively. The total capacity of the siphons is about 17,700 sec.-ft. There is also a side channel spillway 223 ft. long, with a capacity of 5,300 sec.-ft., hence the total spillway capacity is 23,000 sec.-ft., or well above Fuller's 1,000-year flood value for this size of catchment area.

The dam was constructed about 1923 by the Societa Officine Elettriche Genovesi and is built of concrete with plums of serpentine rock embedded therein. In the lower portion of the dam are three large chambers packed with dry rock fill, each chamber being drained as shown in the drawing. The dam also has a general

drainage system consisting of vertical drains in the region of the upstream face, connected by inspection galleries to a discharge gallery. The upstream face is plastered with cement mortar and treated with a waterproofing compound.

The Italian rules for dam construction do not require contraction joints for gravity dams arched in plan, and none are shown on the plans or mentioned in any of the descriptions. A smaller auxiliary dam closing a gap in the reservoir basin is of straight gravity type and is provided with contraction joints.

Outlet capacity

Two outlets are provided through the dam, one a scour outlet of 6-ft. diameter, and a main discharge outlet for emptying the reservoir in case of need. The latter is controlled by a cylinder gate mounted at the top of a stub tower, as shown, and this cylinder gate could be controlled very readily by hydrostatic pressure. The diameter of this outlet is 11 ft. at the cylinder gate, but reduced to about 9 ft. through the dam. The capacity of these two outlets was estimated as 7,000 sec.-ft., which was intended to be available to assist in the discharge of floods, although it appears from the scanty news so far available that time did not permit of such precautionary measures being taken, especially as the operating chamber for the scour outlet was in the body of the dam, and reached only by a gallery.

MOLARE DAM in Italy was a gravity type structure, arched in plan, 150 ft. high. It was built of concrete with three large chambers packed with rock in the lower portion.

Power plant

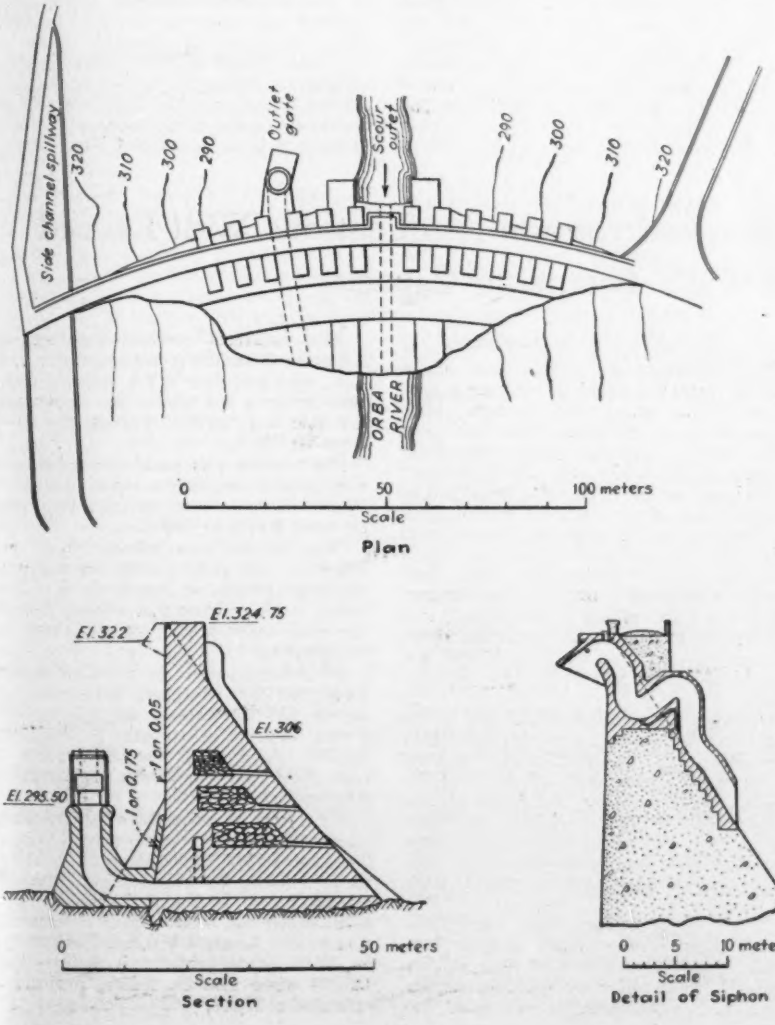
The power plant operated in connection with this dam is supplied by a pressure tunnel about 10 ft. in diameter and 8,900 ft. long, followed by a pipeline, and the head on the turbines varies from 293 ft. to 360 ft., according to the reservoir stage. The power house contains two sets of 9,000 kw. capacity each, operated by double-runner Francis turbines.

Conservative design

It is evident from what is known of this dam that it was of supposedly conservative design, and provided with approved drainage system. The total batter varies from about 0.76 at the top to about 1.00 at the bottom. Exception might be taken to the economizing of cement by substituting dry rock in the core of the dam, although the effect of this in the highest section of the dam is equivalent to a reduction of less than 3 per cent in the mean weight of dam material. The omission of contraction joints, which seems to be the case, would also deny the dam any possible support from arch action, although with such a large radius this action is doubtful, particularly in the lower portions where it is needed.

Probable cause of failure

Any statement of the probable cause of failure can at present be only tentative, but since the dam is built on metamorphic rock of the nature of serpentine, it seems evident that sliding took place due to overload. It appears that the cloudburst was so sudden and of such proportions that no precautions could be taken, and it is conceivable that timber and rubbish brought down by the flood wave partially blocked the siphon spillways, which would normally discharge most floods with comparatively little rise of water level. The sliding factor of the dam as built, with water to crest level and no backwater, would be 0.56. This is based on a weight of concrete of 150 lb. per cu.ft. and of packed rockfill of 120 lb. per cu.ft. A depth of 30 ft. of backwater would have the effect of increasing the sliding factor to 0.64, which is a dangerously high value for a foundation rock of this nature. A possible flow of water of say 3 ft. over the crest, due to partial blockage of the spillways, would further raise the sliding factor to 0.67. Shear stress on the concrete is not excessive. At the base it is 39 lb. per sq.in. and at the level of the floor of the lowest chamber 58 lb. per sq.in.



Washington Highlights

By Paul Wooton

Action of the Interstate Commerce Commission in allowing a 25 per cent reduction in the freight rates on lumber moving to destinations east of the Illinois-Indiana line is expected to have a stimulating effect on building. Transcontinental carriers requested the reduction as an experiment to determine the effect of a substantial rate reduction on the volume of business carried, not only of the commodity involved, but all other commodities which would move if the freight reduction on a basic commodity stimulates a whole industry.

A compromise reached in conference resulted in a real estate loan provision in the banking bill which is expected to contribute to the stimulation of construction industries. As agreed to in conference, real estate loans for terms not longer than five years may be made by national banks on a 50 per cent valuation. Ten year loans may be made on a 60 per cent valuation when installment payments are sufficient to amortize 40 per cent or more of the loan within that period.

The new banking act represents a fundamental change in the Federal Reserve System. Under the new law it becomes a regulator of money supply rather than an agency to help banks in time of stress.

A shortage of thoroughly skilled labor in certain trades is resulting in increased activity on the part of the Federal Committee on Apprentice Training. During the depression the skilled labor supply has been reduced by one half.

Washington, August 20, 1935.

B.&O. Exhibition Building Wrecked by High Wind

The Transportation Building, one of several buildings erected by the Baltimore & Ohio R.R. at Halethorpe, near Baltimore, Md., in 1927 for its Fair of the Iron Horse was wrecked in a thunderstorm on Aug. 13. The building housed an extensive exhibit of railroad equipment including some original locomotives and cars, models, sketches and pictures. The building was completely wrecked and extensive damage was done to the exhibits by the falling walls and roof and by water.

The building was 600x60 and about 18 ft. high at the walls. The walls were of brick, of light construction, generally 2 bricks thick. The roof was of corrugated iron supported by steel trusses anchored by bolts to the walls. The only large openings in the building were large doors at the easterly end through which two tracks passed, and they were closed. The wind, estimated at 60 m.p.h., was from the southwest.

The position of the roof and of the fallen walls indicates that the collapse began by the westerly end of the roof being lifted bodily by suction and moved in a southerly direction, lifting part of the wall with it.

Most of the walls collapsed but the roof trusses in falling landed on locomotives or cars at some points and so did not fall to the ground.

Two Persons Drown as Bridge Over Mississippi Collapses

The collapse of a 131-ft. approach span of the bridge across the Mississippi River at La Crosse, Wis., on Aug. 9 caused the death of two persons as they were trapped in their automobile. Francis Landrieu, an engineer for the United States Government on the Genoa dam below La Crosse, and Mrs. Landrieu were drowned. Lieut. F. S. Blinn, army engineer at the dam, driver of the car, and Miss M. Patre were able to get out of the car and were rescued.

Collapse of the bridge span was due to its end post being struck by Lieut. Blinn's car, a 12-cylinder sedan.

The bridge was built by the city of La Crosse in 1892, but since then has been under the supervision of the state of Wisconsin. Temporary ferry service was instituted across the river, but it was necessary to reroute automobile traffic over other bridges, the nearest of which are at Lansing, Iowa, 30 miles downstream, and Winona, 30 miles above La Crosse.

Jersey City-Brooklyn Tunnel To Be Subject of Hearing

A public hearing to develop opinions and information on a proposesd railroad freight tunnel under New York Harbor from Jersey City to Brooklyn will be held by the Port of New York Authority on September 10. An underwater freight crossing between Long Island and New Jersey was authorized and the general location was fixed, in the statutory plan for the development of the Port of New York as enacted by the states of New York and New Jersey. According to the Port Authority the construction for the tunnel is dependent upon the securing of satisfactory railroad lessees.

Interstate Sanitation Board Holds First Meeting

The first meeting of the members of the recently formed interstate sanitation commission, uniting New York, New Jersey and Connecticut in a joint effort to reduce pollution in the waters adjacent to these states, was held in New York City, August 15. Although congressional consent must be granted before this group will become an official body, plans for action are now being formulated, pending federal approval. Legislation by New York and New Jersey supporting the measure has been enacted, and the latter state has already appointed five commissioners who will represent it on a board of 15 members. Until ratification is made by the Connecticut legislature, the water commission of that state has been given blanket authority to represent it.

The legal status of the commission is not that of an engineering and construction authority, but has been created to coordinate planning on pollution control activity between the communities which border on New York Harbor, Long Island Sound and adjacent waterways. The commission is permitted to bring suit to compel action by any corporation or municipality and to demand a stated rate of progress on the construction of treatment plants. The newly formed commission may not borrow funds, but it will aid in the preliminary surveys and plans which are needed before communities can obtain federal loans and grants. Annual sums for the administration of the compact will be appropriated by the state legislatures and are not to exceed $15,000 each for New York and New Jersey, and $3,300 for Connecticut. Distribution of costs will be made on the basis of 45 per cent for the first named states and 10 per cent to be advanced by the latter.

Mayor LaGuardia stated that New York City was ready to spend $100,000,000 to carry out its part in the program. He pointed out that $2,000,000 had already been used for the construction of the Coney Island sewage treatment work which is now treating 18 m.g.d. of sewage, and $25,000,000 have been approved for the completion of the Ward's Island activated-sludge plant. It is estimated by the commission that $300,000,000 to $360,000,000 will be needed to clean up the metropolitan waters in accordance with two general classifications which designate the purity requirements of water areas used for navigation and those to be adapted for recreational purposes and development of fish life.

The executive committee for the commission was named as follows: Joseph P. Day, chairman; J. Spencer Smith and J. Lester Eisner of New Jersey, Sandford Wadhams, director of the Connecticut State Water Commission and Gerald W. Knight, secretary of the commission and technical adviser to Gov. Hoffman of New Jersey.

Dorr Company Get Contract For Silt Removing Equipment

Contract for the silt removing equipment to be installed at Imperial Dam at the head of the All-American Canal near Yuma, Ariz., has been let to the Dorr Company, Inc., New York, not to the Dow Company as stated in our issue of Aug. 15. The equipment will be built at the Denver plant of the Dorr Company.

Works Program Applications Will Exceed PWA's Financing Capacity

(Washington Correspondence)

MUNICIPAL PLANS for public works are rising to a volume greater than PWA can possibly finance. More than 3,000 project applications have been filed with PWA for grants and loans totaling $750,000,000. State PWA directors anticipate that twice as many more will be submitted within the next six weeks.

Disillusioned by their experience with the CWA program two years ago, many communities are demanding that their projects be handled by PWA rather than WPA and are willing to bear 55 per cent of the cost to support their preference, even on projects that cost less than $25,000 and would ordinarily fall in WPA's jurisdiction.

Arrangements between PWA and WPA field forces, however, are much more harmonious than the relationship between these two organizations has been in Washington. In many states, WPA officials are "graduates" of PWA offices. Nebraska and Illinois are reported to be sore spots but steps have been taken to remedy conditions which have held up programming in those states.

"The policy of the whole administration," Administrator Ickes asserted this week, "is to favor PWA projects as that means a contribution by the communities for local improvements."

This statement received apparent confirmation from WPA Administrator Hopkins, who said that WPA will not undertake projects for which the communities are able and ought to borrow the money from the PWA.

His attitude was plainly revealed when questioned concerning a report that Frederick, Md., intended to switch a local project from PWA to WPA.

"You can bet your bottom dollar," said Hopkins, "that if they withdraw that project from PWA, we won't do it." This seems to be evidence that friction between the rival relief works agencies is at last disappearing.

PWA headquarters in Washington have forwarded for President Roosevelt's approval 974 applications for 45 per cent grants on projects estimated to cost $300,603,343. Applications for 287 projects to cost $55,466,863 had been approved to August 16.

WPA work programs have been submitted piecemeal for every state except Nevada and totaled $837,509,000 August 16. Allotments totaling $234,435,000 had been approved for 33 states and approximately $170,000,000 had been actually released by Comptroller General McCarl. Employment on WPA state projects is estimated at 133,000 while that on federal projects is estimated at 27,000.

Removal of Utilities' Influence Considered In Granting Funds For Municipal Plants

(Washington Correspondence)

SOCIAL DESIRABILITY of removing political influence of utilities in municipal affairs is a factor taken into consideration by PWA in extending grants for construction of municipal power plants, Administrator Ickes indicated on August 20. Asked to explain PWA policy on loans and grants for municipal power plant construction where there is already an existing power service, Mr. Ickes said a city has as much right to decide it wants PWA money for a power plant as for municipal buildings or an airport.

"The only thing we are interested in is if it can justify its request for a grant economically." He continued, "Suppose you were a banker and a city came to you and said that it wanted to build a competing power plant and offered good bonds as security?" Asked if security was the only thing PWA was interested in in such grants, he added that social advantage is also taken into consideration. "A community can afford to pay something to remove from its political affairs the influence power companies sometimes exert," he declared. "Illinois could have afforded to pay a high price to have gotten rid of Insull."

Government upheld

The Administrator denied knowledge of a St. Louis court decision against a PWA loan for a municipal plant on the ground that it involved an improper delegation of legislative power.

The right of the federal government to make loans and grants to municipalities for the construction of power plants was upheld on Aug. 20 by a decision rendered in an injunction suit in the Tenth Circuit Court of Appeals at Denver. The Kansas Gas and Electric Co., of Kansas City, was denied an injunction restraining Independence, Kan., from building a municipal plant with federal funds.

Among recent approval of allotments made by President Roosevelt is a sum of $1,650,909 for the construction of electric power plants in Iowa City, Iowa, and Danville, Va., to be carried out by the PWA. For the Iowa City plant a sum of $413,000 was allotted and the Danville project received an allocation of $1,237,909. These grants represent 45 per cent of the cost of the projects and the remaining 55 per cent, $504,000 for Iowa City and $1,513,000 for Danville, will be financed by loans, making the total cost for the construction $3,667,909. The PWA will handle all details of drawing up the contracts, supervising construction and disbursing funds.

Danville, Va., already owns and operates its own electric supply system, but the present plant is becoming obsolete. The plans call for the construction of a dam and storage reservoir, a hydro-electric power plant and a 60-mi. transmission line to Danville. The franchise of the utility company now serving Iowa City has expired, and the allocation is to be used in the construction of a steam-electric power plant and distribution system.

According to Administrator Ickes the National Resources Board report on Oklahoma's proposed $15,000,000 Grand River project has been sent to the White House for action by President Roosevelt who requested the investigation. The Administrator also announced that he had received protests that construction of the Florida Gulf Canal at sea level would ruin all down-stream water in the state, but did not recollect from whom the protests came.

Flood control projects also approved

The President also approved an allotment of $2,039,700 to the Corps of Engineers for ten flood control projects in Arkansas, Georgia, Kansas, Louisiana and Oklahoma. For increasing levees to an average height of 12 ft. for a distance of 6 mi. along the White River, in Clarendon, Ark., a sum of $292,000 has been allotted. For improving four miles of levees in the Long Prairie district, Lafayette County, Ark., a sum of $22,000 has been allocated. An allotment of $596,500 has been made for increasing the cross-section of the river at critical points between West Point and Langdale, Ga.; the construction of an additional span in the highway bridge at West Point is also included in this work. For enlargement and extension of existing levees to protect Arkansas City, Kan., from floods of the Arkansas and Walnut rivers an allotment of $94,000 has been made. Construction of a small dam for flood control on Black Bayou, Bossier Parish, La., will be carried on under an allocation of $125,000. For dredging of a pilot channel in the Red River in the same parish, a sum of $81,200 has been set aside. For other dredging and levee work in Louisiana a total of $521,000 has been set aside, and for the construction of levees along both banks of the Arkansas River in Tulsa, Okla., a sum of $308,000 has been set aside.

Highway allotments also approved

Relief works projects approved by the President include the following: Drainage systems, Gray's Harbor, Wash., $205,000; community sanitation program in twenty Utah counties, $410,284; Anchorage-Matanuska, Alaska, highway, $100,000; Highways in Matanuska Valley, $125,000; Alabama Highway Commission, $1,499,000; Wisconsin, various projects, $253,396; Oregon, various projects $138,584; Colorado, various projects, $248,525; Vermont, various projects, $127,834; New Jersey, various projects, $373,706.

Only one Rhode Island project defeated

Applications covering $7,300,000 of building construction by the state of Rhode Island have been filed with the PWA state engineer at Providence. The projects were authorized in a recent bond election when, contrary to premature reports, only one project eligible for PWA financing, a state auditorium to cost $825,000, was defeated. Other projects defeated were of the type that would have fallen under WPA, as they are not eligible either for PWA grants or loans, although designated on the ballots as PWA projects.

For the authorized projects, grants of 45 per cent from the new relief works appropriation will be supplemented by loans for the amount of the bond issues.

SOCIETY CALENDAR

AMERICAN PUBLIC HEALTH ASSOCIATION, annual meeting, Milwaukee, Wis., October 7-10, 1935.

NATIONAL SAFETY COUNCIL, annual congress, Louisville, Ky., October 14-18, 1935.

PUBLIC WORKS ENGINEERING CONFERENCE, joint meeting of the American Society of Municipal Engineers and International Association of Public Works Officials, Cincinnati, Ohio, October 14-16.

INSTITUTE OF TRAFFIC ENGINEERS, Sixth annual meeting at Louisville, Ky., October 15-16.

AMERICAN SOCIETY OF CIVIL ENGINEERS, fall meeting, Birmingham, Ala., Oct. 16-18.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, White Sulphur Springs, W. Va., October 16-18, 1935.

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual convention, Miami, Fla., December 9-12.

ROCKY MOUNTAIN SECTION, American Water Works Association, annual meeting, Denver, Colo., September 16-18.

NEW ENGLAND WATER WORKS ASSOCIATION, fall convention, Providence, R. I., September 17-20.

NEW ENGLAND AND NEW YORK STATE SEWAGE WORKS ASSOCIATIONS, joint meeting at Schenectady, N. Y., October 4-5.

EXAMINATIONS for registration of engineers and land surveyors will be held in the near future as follows:

IOWA—By Iowa State Board of Engineering Examiners at the State House, Des Moines, Sept. 4-5.

LOUISIANA—By Louisiana State Board of Engineering Examiners at the offices of the Board, New Orleans, Sept. 9-10.

Formation of Water Districts Favored by Three Utah Cities

The formation of metropolitan water districts to finance and carry forward plans for additional domestic water supplies was approved by three Utah cities, Salt Lake City, Provo and Orem, at elections held on Aug. 15. The state legislature recently passed an act authorizing the creation of water districts and the law has been declared constitutional by the state supreme court in a friendly suit taken to the court in advance of the election. A district may include only one city or may include several contiguous communities. A district may issue bonds to finance new construction and has taxing power not limited by the debt limit of the communities within the district, but it is expected that the new work now under consideration can be financed by income from water sales without resort to taxation.

Contractors Equipment Show Opened in Long Island City

An exhibit of contractors' machinery and equipment, sponsored by The Forsythe Equipment Co., Inc., was opened on August 16 and will run until September 16 at 43rd St. and Northern Blvd., Long Island City, N. Y.

Among the manufacturers who are represented at the exhibit are the Manitowoc Engineering Works, Worthington Pump & Machinery Corp., Michigan Power Shovel Co., Novo Engine Co., Hercules Motor Co., American Steel & Wire Co., Cyclone Fence Co. The exhibit will feature a wide range of improved types of construction equipment, such as crawler shovels, cranes, truck shovels and cranes, portable air compressors, and rock drills.

Large Exhibition Building To Be Built in London

One of the world's largest permanent exhibition and entertainment centers is to be constructed in London, England, at an estimated cost of $6,000,000. The building will adjoin the Earls Court Station, a centrally-located junction on the Underground Railway System. The building site of about eighteen acres has been leased from the London Transport Board by a newly-formed company, Earls Court Ltd. The building itself will be a concrete structure, 80 ft. high, providing more than twelve acres of exhibition space on two floors. An interesting feature of the plan is a provision for a clear space of 2½ acres on the ground floor, unbroken by columns.

The building, which will provide seating accommodations for 25,000, will house such shows as the British Industries Fair, the Ideal Home Exhibition, Motor Show and a swimming pool 200 ft. by 100 ft.

Personals

FRANK G. MULLEN, who has been serving as resident engineer inspector assigned to the Nashville, Tenn., waterworks project, has been appointed engineer examiner for the PWA in Tennessee.

E. F. GALLAGHER, who has for five years been the engineer-manager of the New England District of the Brick Manufacturers Association of America, has resigned his position to be effective Aug. 31, and will take up duties as engineer with the New England Brick Co., Boston, Mass. He will be succeeded by Frederick Heath, Jr.

CAPT. ORVILLE E. WALSH, Corps of Engineers, who had charge of Missouri River work at Hermann, Mo., to Rulo, Nebr., will succeed CAPT. THEODORE WYMAN, JR., as assistant to COL. R. C. MOORE, division engineer, at Kansas City. Capt. Wyman has been transferred to Los Angeles, where he will replace MAJ. H. H. STICKNEY, who is to become Corps Area Engineer at Baltimore, Md.

W. T. BOWMAN, county engineer, Kittitas County, Wash., for the past twelve years, has resigned to accept a position as supervising engineer, Soil Conservation Service, in the district from Cashmere, Wash., to Simnisco, Ore.

A. C. POLK, who was vice president in charge of construction operations for the Allied Engineers, Inc., New York City, until 1931, has opened offices as a consulting engineer in Birmingham, Ala. Previous to his nine years as president of the Dixie Construction Co. of Alabama, which was later merged with the Allied Engineers, Inc., Mr. Polk was for 17 years with Sanderson & Porter, engineers of New York City.

JOHN L. BACON, who has been SERA director for San Diego county, Calif., has been named as chief engineer in charge of field operations of the California Works

CATWALK CABLES STRUNG ACROSS THE GOLDEN GATE

Construction work on the Golden Gate bridge, San Francisco, Calif., enters a new stage as catwalk cables are strung across preparatory to the cable spinning. The footbridge cables for the Golden Gate bridge, totaling 25 in number, were placed between Aug. 2 and Aug. 15. Each cable was towed across the Gate separately and separately was hoisted from the bottom of the bay to the top of the 746-ft. towers. The cables are 1⅞ in. in diameter and have a total length of 4,274 ft. in the 4,200-ft. span. One of the accompanying pictures, showing the anchoring of footbridge cable no. 1, was taken on top of the north tower looking westward toward the horizon on the Pacific. The other view, taken from Old Fort Point, on the south side of the bay, shows the completed towers with the rigging for the cable stringing work in place at the top.

Progress Administration, with headquarters in San Francisco. Mr. Bacon is a former mayor of San Diego, and during the war was a captain of engineers.

CARL A. BAUER, engineer examiner of public works in Washington, has been appointed as Illinois director of the PWA by President Roosevelt. For several years Mr. Bauer was general superintendent of construction for the Chicago Transfer Clearing Co., and for 12 years was architect and engineer for a plow manufacturing concern in Racine, Wis.

WENDELL C. WYATT has been appointed resident engineer for Black & Veatch, consulting engineers, Kansas City, Mo., on a sewage disposal project in Hot Springs, Ark. Previous to joining the firm of Black & Veatch at the beginning of this year, Mr. Wyatt was an assistant engineer for the water conservation department, Kansas, on acid mine water pollution of southeastern Kansas streams.

RICHARD S. HOLMGREN, chief assistant engineer for H. K. Barrows, Boston, Mass., has been named chief engineer of the New Hampshire Water Resources Board. The New Hampshire Water Resources Board, which was established June 19, 1935, is to investigate facilities for storing surplus water and for conserving and controlling it. In 1927-28 Mr. Holmgren was district water supply engineer on hydraulic studies for the metropolitan district water supply commission of Boston on the Swift River diversion project and following the 1927 flood he developed a complete plan for flood prevention on Vermont streams and has made reports on the water resources of the streams flowing into the Atlantic Ocean, north of the Susquehanna River, for the National Resources Board.

FRANCIS H. DRYDEN, city engineer of Salisbury, Md., has been appointed State Works Progress Administrator for Maryland. He succeeds JOHN N. MACKALL, who recently resigned. Mr. Dryden served as assistant general superintendent of construction at the Niagara Falls power plant prior to becoming city engineer of Salisbury. He also has served as consulting engineer for a number of municipalities in Maryland and Delaware and as a member of the Water Resources Commission of Maryland.

CONSTRUCTION STATISTICS OF THE WEEK

ENGINEERING construction awards for the week total $29,438,000 which is fifteen per cent higher than the average week to date but below the two preceding record high weeks. This total is made up of $2,956,000 for private construction and $26,482,000 for public work of which $15,184,000 is federal and $11,298,000 state and municipal. Corresponding values last year were: total $18,271,000, private, $3,382,000, public, $14,889,000, of which federal was $5,719,000, state and municipal $9,170,000.

Earthwork and waterway awards again account for the high volume to the extent of $12,326,000. Streets and roads contribute the next highest volume with $5,954,000, a drop from last week but higher than preceding weeks. Public buildings dropped to $4,850,000 for the week while waterworks, sewerage, bridges, industrial buildings, commercial buildings and unclassified all hit close to the $1,000,000 mark.

The larger awards for the week include an 8-story jail in New York City, $754,000; U. S. Post Office, Wilmington, Del., $686,000; highway awards by Michigan, $1,473,000 and by Kentucky, $1,625,000; grade crossing elimination by Staten Island Rapid Transit Railroad Co., Staten Island, N. Y., $631,000; service grease catcher and galleries building at Easterly Sewage Treatment Plant, Cleveland, Ohio, $829,000; Lock 14, Mississippi River, LaClair, Ia., $1,186,000; desilting works, All-American Canal, Yuma, Ariz., $565,000; dredging San Diego Bay, San Diego, Calif., $1,217,000; Lock 2, Caloosahatchee River, Moore Haven, Fla., $637,000; three dredging awards for New York-New Jersey channels, $3,154,000; dam 7, Mississippi River, LaCrosse, Wis., $1,946,000 and relocating B & O R. R., by U. S. Engineers on account of Bolivar Reservoir, Zanesville, Ohio, $449,000.

New capital for the week includes $3,245,000 in state and municipal bond sales, $25,744,000 in PWA allotments for non-federal work and $85,257,000 for federal work including the WPA percentage for larger construction operations, and $59,868,000 for 351 public building projects to be paid out of $60,000,000 emergency construction fund authorized under the Second Deficiency Act approved August 12, 1935.

CONTRACTS
(Thousands of Dollars)

	Weekly Average August 1934	Prev. 4 Weeks	Week Aug. 22 1935
Federal Government	$6,382	$12,050	$15,184
State and municipal	11,400	12,540	11,298
Total public	$17,782	$24,590	$26,482
Total private	4,041	7,310	2,956
Week's total	$21,823	$31,900	$29,438
Cumulative to date:			
1934...$903,418,000	1935...$875,260,000		

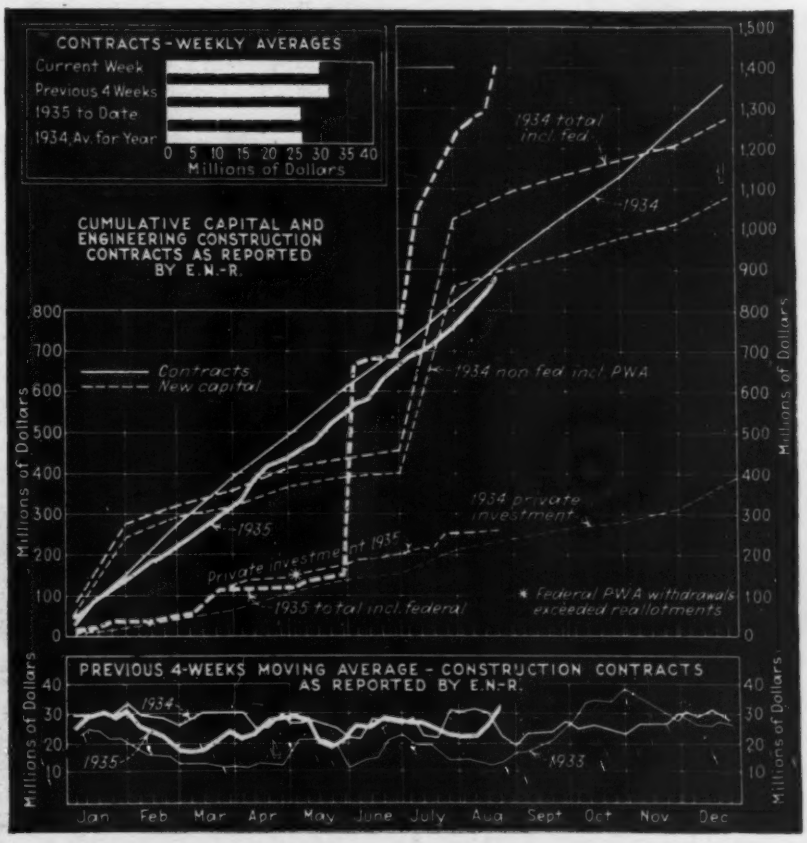
NEW PRODUCTIVE CAPITAL
(Thousands of Dollars)

1935	Week Aug. 22	Cumulative
State and municipal	$3,245	$262,145
PWA allotments, S&M.	25,744	274,016
RFC loans, S&M.	.....	36,084
Corporate issues	.....	18,124
PWA private	.....	8,629
Local contrib. to WPA.	508	3,464
Total non-federal	$29,497	$602,462
PWA federal	85,257	804,560
Total new capital	$114,754	$1,407,022
Cumulative to date:		
1934..$1,083,936,000	1935..$1,407,022,000		

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, including the special highway funds; PWA private loans, and allotments for federal construction, deficiency act funds. An arbitrary percentage (25%) of the WPA allotments and local contributions to WPA work is included to allow for the capital additions through the Works Progress Administration division of the new program.

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
Aug., 1935	195.10	93.82	July, 1935	96	42
July, 1935	195.18	93.82	June, 1935	122	54
Aug., 1934	198.40	95.37	July, 1934	128	56
1934(Av.)	198.10	95.23	1934(Av.)	114	50
1933(Av.)	170.18	81.80	1933(Av.)	102	47
1932(Av.)	156.97	75.45	1932(Av.)	127	56


CONTRACTS - WEEKLY AVERAGES
Current Week
Previous 4 Weeks
1935 to Date
1934 Av. for Year
0 5 10 15 20 25 30 35 40
Millions of Dollars
CUMULATIVE CAPITAL AND ENGINEERING CONSTRUCTION CONTRACTS AS REPORTED BY E.N.-R.
Contracts
New capital
1934 total incl. fed.
1934
1934 non-fed. incl. PWA
1934 private investment
1935
Private investment 1935
1935 total incl. federal
* Federal PWA withdrawals exceeded reallotments
Millions of Dollars
PREVIOUS 4-WEEKS MOVING AVERAGE - CONSTRUCTION CONTRACTS AS REPORTED BY E.N.-R.
1934
1935
1933
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec

Current Construction Unit Prices

Pneumatic Caissons for Corewall

CONSTRUCTION of 37 pneumatic caissons, each 9 ft. wide by 45 ft. long, began in May, 1935, with the award of contract by the Boston Metropolitan District Water Supply Commission for the building of the concrete corewall for the main dam of Quabbin Reservoir.

The present contract is scheduled for completion in 19 months and provides an interesting unit-price comparison with the same type and size caissons erected for the corewall of Quabbin Dike, the construction of which began in January, 1933. On a caisson unit basis, the previous corewall contract cost approximated $36,270 each for the 27 caissons sunk for the dike compared with the present indicated unit cost of $35,970.

Nine bids were received ranging from the contract low of $1,330,765 to a high of $1,818,000. West Construction Co., who were the successful bidders on the dike corewall, were fourth on the present set-up. The following tabulation lists the quantities, unit prices and comparisons as indicated above: (A) C. J. Maney Co., Inc., Boston, and B. Perini & Sons, Inc., Framingham, Mass., combined bid and contract, $1,330,765. (B) Dominion Construction Co., Boston, Mass., $1,406,104. (C) West Const. Co. (December, 1932, units on Quabbin Dike, *ENR*, Jan. 12, 1933).

PNEUMATIC CAISSON COREWALL, QUABBIN RESERVOIR

	A	B	C
1. Clearing and grubbing—25 acres	$75.00	$90.00	.....
2. Earth excavation, open-cut—230,000 cu.yd.	.65	.26	.19
3. Rock excavation as boulders, open-cut—7,000 cu.yd	.65	.55	.50
4. Rock excavation as ledge, open-cut—6,000 cu.yd	7.50	6.00	8.00
5. Stripping—60,000 cu.yd	.65	.28	.20
6. Embankment, unconsolidated—40,000 cu.yd	.05	.15	.10
7. Embankment, pervious consolidated—190,000 cu.yd	.05	.09	.12
8. Embankment, rolled impervious, core—90,000 cu.yd	.60	.60	.....
9. Embankment, rolled impervious, non-core—40,000 cu.yd	.60	.60	.36
10. Stone fills—65,000 cu.yd	1.00	.77	.45
11. Pumping (unit price fixed)—(mil. ft.-gal.—300,000)	.10	.10	.10
12. Control surface waters—lump sum	4,600.00	10,000.00	5,600.00
13. Earth excav. corewall, bottom open-cut to El. 300—35,000 cu.yd	7.00	7.00	5.85
14. Earth excav. corewall, below El. 300—5,000 cu.yd	7.00	15.10	13.00
15. Rock excav. caissons, above El. 300—3,000 cu.yd	11.0(	9.50	9.00
16. Rock excav. caissons, below El. 300—1,000 cu.yd	11.00	20.00	14.00
17. Rock excav. corewall, below open-cut, non-caisson—300 cu.yd	10.00	10.00	8.00
18. Prepare rock surface, caissons, above El. 300—1,100 sq.yd	2.00	9.00	2.00
19. Prepare rock surface, caissons, below El. 300—650 sq.yd	2.00	9.00	5.00
20. Prepare rock surface, non-caisson—600 sq.yd	2.00	4.00	1.00
21. Concrete, not under air pressure—50,000 cu.yd	6.00	7.40	5.60
22. Concrete, under air pressure—7,000 cu.yd.	6.00	6.70	5.50
23. Impervious fill, caissons—5,000 cu.yd	1.00	1.08	1.00
24. Impervious fill, corewall, below open-cut, non-caisson—300 cu.yd	1.00	.68	.65
25. Drill holes, rock, masonry—12,000 lin.ft.	.80	1.40	1.00
26. Furnish, place grout—1,000 cu.yd	11.00	15.00	7.00
27. Portland cement—90,000 bbl	2.20	2.70	2.70
28. Maintain highway—lump sum	2,000.00	2,500.00	.....
29. Maintain engineer's office—19 months	60.00	200.00	.....
30. Clean-up—lump sum	1,000.00	2,500.00	1,000.00

Dam No. 26, Mississippi River

DAM 26, on the Mississippi River near Alton, Ill., the largest unit to date of the canalization program of the upper Mississippi, is now under construction with the award of contract in April to the low bidder, Engineering Construction Co. of New York, N. Y. This dam will have four roller gates and will be similar in construction to others under way and contemplated on the Mississippi. The range on the four bids submitted was from the contract low of $4,865,717 to a high of $5,791,971. The project comes under the jurisdiction of Capt. B. M. Harloe, U. S. District Engineer, St. Louis, Mo. Following are the totals and unit prices of the three low bidders: (A) Engineering Construction Corp., New York, (contract) $4,865,717; (B) United Construction Co., Winona, Minn., $5,062,027; (C) Dravo Contracting Co., Pittsburgh, $5,494,431.

UNIT PRICES—DAM NO. 26, MISSISSIPPI RIVER

Item	Bidder A	Bidder B	Bidder C
1. Cofferdam—1,816 lin.ft. work enclosed	$300.00	$324.27	$330.00
2. Clearing—95 acres	60.00	52.57	70.00
3. Excavation, common—85,300 cu.yd	.60	.60	2.00
4. Excavation, top soil—30,000 cu.yd	.30	.39	.50
5. Fill—8,770 cu.yd	1.00	1.25	.30
6. Embankment, earth—347,000 cu.yd	.30	.33	.60
7. Piling, round timber—419,000 lin.ft	.55	.57	.70
8. Piling, concrete—1,036 lin.ft	3.00	2.63	3.00
9. Piling, steel sheet, type A—92,500 sq.ft.	1.40	1.49	1.60
10. Piling, steel sheet, type B—119,000 sq.ft.	1.05	1.12	1.20
11. Pile loading tests—33, each	500.00	484.76	200.00
12. Timken, fir, creosoted—28.8 M.B.M.	150.00	197.13	300.00
13. Timber, oak, white—22.5 M.B.M.	140.00	130.21	220.00
14. Lumber, mattress—384 M.B.M.	90.00	71.61	80.00
15. Stone, derrick—24,000 cu.yd	7.00	5.23	6.00
16. Stone, riprap—20,500 cu.yd	7.00	5.31	6.00
17. Stone, crushed—6,300 cu.yd	4.20	3.84	5.00
18. Concrete, class A—3,880 cu.yd	25.00	29.53	25.00
19. Concrete, class B—94,900 cu.yd	12.75	13.17	16.00
20. Structural steel, service bridge—2,055,000 lb	.06	.0586	.06
21. Struct. steel, roller gate, movable parts—1,020,000 lb	.09	.093	.09
22. Struct. steel, tainter gate, movable parts—5,300,000 lb	.08	.0825	.065
23. Struct. steel, misc.—2,290,000 lb	.07	.075	.092
24. Steel, concrete reinforcing—2,714,000 lb.	.05	.051	.06
25. Steel, corrosion-resisting—105,000 lb	.45	.48	.50
26. Steel, struct. nickel—69,000 lb	.09	.118	.15
27. Steel, cold-rolled—148,000 lb	.11	.15	.12
28. Steel, machine—3,960 lb	.20	.26	.15
29. Steel, chromium—478,000 lb	.10	.096	.12
30. Steel, manganese—163,000 lb	.06	.079	.07
31. Steel, struct. forged eyebars—700,000 lb.	.10	.10	.11
32. Forgings, steel, regular carbon—151,000 lb	.10	.12	.16
33. Forgings, steel alloy—276,000 lb	.13	.15	.14
34. Castings, steel, grade "O"—82,600 lb	.08	.099	.10
35. Castings, steel, grades 1, 2, 3—594,000 lb.	.12	.138	.13
36. Castings, alloy steel—68,600 lb	.20	.243	.23
37. Bronze—49,300 lb	.40	.525	.40
38. Copper—5,980 lb	.50	.54	.60
39. Non-ferrous metals, misc.—9,320 lb	.50	.39	.225
39a. Pipe, steel, black std. 2 in—73 lin.ft.	3.00	2.10	1.00
40. Pipe, steel, black, std. 2½ in.—160 lin.ft.	3.50	2.37	2.00
41. Pipe, W.I., black, std. 3 in.—1,340 lin.ft.	3.60	2.02	2.00
42. Conduit, fibre, 3 in.—1,690 lin.ft	.60	.63	.60
43. Conduit, fibre, 4½ in.—66 lin.ft	1.00	1.13	1.00
44. Conduit, rigid metal, 1 in.—60 lin.ft	1.00	.92	.70
45. Conduit, rigid metal, 1½ in.—2,310 lin.ft.	1.20	.815	.70
46. Electrical grounding system—total	500.00	241.81	250.00
47. Crane rack, 80 lb. rail, complete—1,890 tr.ft	3.00	3.94	3.60
48. Handrail, steel pipe, complete—2,050 lin.ft	2.00	2.63	3.00
49. Floor plating, steel, non-skid—249,000 lb.	.055	.072	.075
50. Floor grating, steel, welded or riveted—3,900 sq.ft	1.00	1.31	1.50
51. Rubber seals, moulded—26,300 lb	.80	1.05	.90
52. Steel wire rope 1¼ in. dia.—44 lin.ft	1.00	1.31	1.00
53. Rope, braided cotton, 1 in.—1,000 lb	.10	.13	1.00
54. Operating machines; roller gate, incl. hoisting chain, elec. equipt., wiring—3, each gate	24,300.00	20,107.00	21,400.00
55. Roller gate spare parts—total	12,500.00	13,142.00	12,900.00
56. Roller gate operating house, complete—4 each	6,000.00	7,090.00	6,300.00
57. Operating machines; tainter gates, incl. hoisting chains, elec. motors and brakes—30, each gate	13,766.00	15,560.00	12,000.00
58. Tainter gate spare parts—total	13,500.00	14,945.00	10,800.00
59. Elec. heating system, complete, roller gate—3, each	3,000.00	4,074.00	2,500.00
60. Elec. for tainter gates—16, each gate	600.00	920.00	550.00
61. Central control station structure, complete—total	25,000.00	28,379.00	23,000.00
62. Equipment, Pier No. 37 storage room—total	700.00	352.20	400.00
63. Temporary construction buildings—total.	2,500.00	3,718.00	5,000.00
64. Move telephone lines—total	600.00	1,323.00	1,000.00
65. Install locomotive crane on service bridge—2, each	1,300.00	1,051.00	1,200.00
66. Install flat cars on service bridge, storage yd.—total	700.00	553.00	500.00
67. Cored concrete specimens—100 lin.ft	20.00	26.28	6.00